33a

Harry Arthur Shipp.
71 Flora St.
St. Thomas Ont.

# I. C. S.
# REFERENCE LIBRARY

A SERIES OF TEXTBOOKS PREPARED FOR THE STUDENTS OF THE INTERNATIONAL CORRESPONDENCE SCHOOLS AND CONTAINING IN PERMANENT FORM THE INSTRUCTION PAPERS, EXAMINATION QUESTIONS, AND KEYS USED IN THEIR VARIOUS COURSES

## VAUCLAIN COMPOUND LOCOMOTIVES
## CROSS-COMPOUND LOCOMOTIVES
## TANDEM AND BALANCED COMPOUND LOCOMOTIVES
## TRAIN RULES
## CAR LIGHTING
## CAR HEATING
## ELECTRIC HEADLIGHT



SCRANTON
INTERNATIONAL TEXTBOOK COMPANY
60

PRINTED IN THE UNITED STATES. 71

# PREFACE

Formerly it was our practice to send to each student entitled to receive them a set of volumes printed and bound especially for the Course for which the student enrolled. In consequence of the vast increase in the enrolment, this plan became no longer practicable and we therefore concluded to issue a single set of volumes, comprising all our textbooks, under the general title of I. C. S. Reference Library. The students receive such volumes of this Library as contain the instruction to which they are entitled. Under this plan some volumes contain one or more Papers not included in the particular Course for which the student enrolled, but in no case are any subjects omitted that form a part of such Course. This plan is particularly advantageous to those students who enroll for more than one Course, since they no longer receive volumes that are, in some cases, practically duplicates of those they already have. This arrangement also renders it much easier to revise a volume and keep each subject up to date.

Each volume in the Library contains, in addition to the text proper, the Examination Questions and (for those subjects in which they are issued) the Answers to the Examination Questions.

In preparing these textbooks, it has been our constant endeavor to view the matter from the student's standpoint, and try to anticipate everything that would cause him trouble. The utmost pains have been taken to avoid and correct any and all ambiguous expressions—both those due to faulty rhetoric and those due to insufficiency of statement or explanation. As the best way to make a statement, explanation, or description clear is to give a picture or a

diagram in connection with it, illustrations have been used almost without limit. The illustrations have in all cases been adapted to the requirements of the text, and projections and sections or outline, partially shaded, or full-shaded perspectives have been used, according to which will best produce the desired results.

The method of numbering pages and articles is such that each part is complete in itself; hence, in order to make the indexes intelligible, it was necessary to give each part a number. This number is placed at the top of each page, on the headline, opposite the page number; and to distinguish it from the page number, it is preceded by a section mark (§). Consequently, a reference, such as § 3, page 10, can be readily found by looking along the inside edges of the headlines until § 3 is found, and then through § 3 until page 10 is found.

International Correspondence Schools

## CONTENTS

| | |
|---|---|
| ORANGE | *Atmospheric Pressure* |
| BLUE | *Live Steam* |
| LIGHT BLUE | *Exhaust Steam* |
| PURPLE | *Intermediate Pressure Steam* |

KEY TO THE COLOR PLATES

13180

# VAUCLAIN COMPOUND LOCOMOTIVES

## INTRODUCTION

### GENERAL DISCUSSION

#### DEFINITIONS

**1.** A **compound engine** is one in which steam is first admitted into one cylinder and expanded, after which it is exhausted into another and larger cylinder, in which it acts on a second piston and is again expanded; the steam is thus expanded more than it would be if used in but one cylinder. The smaller cylinder into which the steam is first admitted is called the *high-pressure cylinder*, since its piston is operated by high-pressure steam direct from the boiler. The steam that is admitted into the second, or larger, cylinder has had its pressure reduced considerably by expansion; hence, the larger cylinder is called the *low-pressure cylinder* on account of its piston being operated by steam of a lower pressure than that used in the smaller cylinder. An engine that has only one cylinder in which to expand the steam is said to be a *single-expansion*, or *simple*, *engine*. The ordinary standard locomotive consists of two simple engines in which the steam is expanded once and then discharged into the atmosphere. An engine that has two cylinders in which to expand the steam, one of which discharges into the other, is said to be a *double-expansion*, or *compound*, *engine*. Some engines have three or even four cylinders, in which the steam passes from

one to another and is expanded as many times as there are cylinders; but, while these, strictly speaking, are compound engines, they are not called by that name, but are distinguished from the double-expansion engine by the names *triple expansion* and *quadruple expansion*, respectively, common usage applying the name of *compound* to the double-expansion engine only.

---

### DIFFERENCE BETWEEN COMPOUND AND SIMPLE LOCOMOTIVES

**2.** The compound locomotives, used in this country, are of the double-expansion types, and have either one or two cylinders for each side, depending on the design of the locomotive. Those of the two-cylinder type have a cylinder placed on either side like a simple locomotive, the high-pressure cylinder exhaust passage being connected to the steam chest of the low-pressure cylinder by means of a receiver placed in the extended front end. These locomotives are known as *cross-compounds*.

Those of the four-cylinder type have a compound engine on each side; that is, there is a high-pressure and a low-pressure cylinder on each side of the locomotive. Where the two cylinders are placed one above the other, or side by side, the steam flows from the high-pressure into the low-pressure cylinder through suitable passages, and its flow is controlled by a valve located in the cylinder saddle; these are known as *non-receiver*, or *continuous-expansion*, *compounds*. Some of the four-cylinder compounds have the two cylinders for each side placed one above the other and the pistons connected to the same crosshead. Others have the cylinders side by side, one piston being connected to a crankpin in the driving wheel, while the other piston is connected to a crank in the axle inside the frame; this type of compounds, called *balanced compounds*, has four crossheads and four main-rod connections. Also, there are four-cylinder compounds having the high-pressure cylinder ahead of and in a direct line with the low-pressure cylinder, so that both pistons are attached to one piston rod and connected to the same crosshead and

crankpin. These are known as *tandem compounds*, because the cylinders are placed *tandem*, or in the same line one ahead of the other.

All four-cylinder compounds are double-expansion, non-receiver compounds; that is, the steam exhausts from the high-pressure cylinder through the valve direct into the low-pressure cylinder instead of exhausting into a receiver.

The general construction of a compound locomotive is practically the same as that of a standard simple locomotive; in the four-cylinder types, however, there is a difference in the arrangement of the cylinders, pistons, crossheads, and valves; but the boiler, frames, truck wheels, driving wheels, and valve gear are the same as those of a simple locomotive.

---

## ADVANTAGES OF THE COMPOUND

**3. Adaptability to Different Classes of Service.** The advantages of the compound over the simple engine depend to a considerable extent on the class of service; in general, the greatest economy will be obtained when the work is hardest and most constant, and the speed moderate. As the load decreases and the speed increases, the economy of the compound decreases, until, at a point approaching light road service and high speed, the compound will show no economy over the simple engine. The compound will probably show to the best advantage in heavy freight service on level divisions where the engine can be loaded to its most economical point on both out-trips and in-trips. Compounds, as a rule, do not "drift" as easily as simple engines; when running on a down grade with steam shut off, the pistons (especially the low-pressure pistons) act as air compressors, drawing air in from the atmosphere through the relief valves and forcing it out through the exhaust pipe and up the stack, thus producing a draft through the fire at a time when no steam is used and practically no draft is required. The consequence is that considerable coal is wasted while drifting, and the economy of compounds is reduced considerably at such times. It is due to this loss while drifting that a compound is not as economical on hilly

as on level divisions. Another reason is that an engine can only save coal during the time coal is being used, so that, if steam is worked throughout the whole run on both the in-trips and out-trips, the compound will make a better showing than it will if steam is only worked during a part of each trip. Pumping air through the cylinders adds to the internal resistance of the engine and is therefore in the nature of a brake.

The compound is advantageous in heavy, fast passenger service also, and especially so on the very fast trains. The probable reason for this is that such service requires so much power that the boiler of the simple engine is overtaxed, and to supply the necessary steam, it must work at a very wasteful rate of combustion; whereas the compound, which requires less steam to do the work, generates steam at a much less rate; hence, with greater economy.

**4. Other Advantages.**—In addition to the saving of fuel, the compound has other advantages over the simple engine. Since it does its work with less steam than the simple engine, it necessarily must use less coal and less water. The saving in water is a great advantage, especially in localities where the supply is limited or where the water is bad. On account of using less water than the simple engine, it is often possible for a compound to make a longer run between supplies—and so avoid taking water that would cause foaming. By using the good water only, less sediment will collect in the boiler, which will steam more freely and the boiler can be run for a longer period of time without being washed out. With a given quality of water, good or bad, the amount of sediment in the boiler of a compound locomotive will be less than in the boiler of a simple one, because the compound uses less steam in doing the same amount of work.

**5.** The compound has still another advantage over the simple locomotive, because in times of emergency it can be made to increase its (compound) tractive force 25 to 30 per cent. In general practice it is customary to make this maximum tractive power of compound (when working as such)

and of simple locomotives about 22 per cent. of the adhesive weight (the weight on the rails under the drivers), in order that all weather and rail conditions may be met without causing excessive slipping. The maximum tractive force of the simple engine cannot be varied, but that of the compound can. The tractive force of four-cylinder compounds is increased by admitting live steam at a reduced pressure into the low-pressure cylinders; while with two-cylinder compounds it is increased by converting the locomotive into a simple locomotive, allowing the high-pressure exhaust to go directly into the atmosphere, and live steam at a reduced pressure to be admitted into the low-pressure cylinder. This, in some cases, will increase the power of the locomotive 25 or 30 per cent. Of course, this increased power is not to be used under ordinary conditions, but only in emergencies, such as in starting a very heavy train, or when in danger of stalling on a grade. It has been found that the adhesion between the drivers and the rails increases considerably, and that at such times, under certain conditions, the tractive power can be run up to 30 per cent., or more, of the adhesive weight without danger of slipping the wheels—a gain of 8 per cent. At such times the compound can utilize its reserve power, and will thus be able to haul a load that would stall a corresponding simple engine.

## HOW ECONOMY IS EFFECTED

**6. Object of Compounding.**—The principal object in compounding locomotives is to effect a saving in fuel; to do this, the compound must use less coal than a simple locomotive doing the same work. The economy of the compound locomotive is due: (1) to the higher steam pressures that can be used advantageously; (2) to reduce cylinder condensation; (3) to greater expansion of the steam, the initial pressure often being 200 pounds, while the exhaust steam escapes at a pressure that is only sufficient to maintain a proper draft through the fire; and (4) to a slower rate of combustion in the firebox. Of course, since the compound and simple locomotives are being compared for fuel economy, everything

that will effect that economy must be considered; in other words, both the boiler and engine must be considered.

**7. High Pressures.**—Both the size and the weight of the simple locomotive have been increased greatly within the last few years, and the construction and quality of the material used have been improved so as to permit the use of steam at higher pressures. This has had the result of raising the pressure from 120 or 130 pounds to 180 or 220 pounds; but, owing to the limitations of its stroke, cut-off, and rate of expansion, the simple engine is unable to fully realize the advantages of pressures above that amount. In fact, it has been found that the economy of a simple engine using steam at 180 pounds is as great as, if not greater than, when using steam at 200 pounds. Of course, increasing the boiler pressure increases the power of an engine, but, on the other hand, since the rate of expansion remains the same, the pressure at which the exhaust steam escapes to the atmosphere and the back pressure in the cylinders increase also; hence, the amount of heat wasted increases with the pressure, so that no advantage is gained by increasing the pressure above a certain point. If greater expansion could be obtained without increasing the cylinder condensation, greater economy would result, but this is not possible with the simple engine.

**8. Cylinder Condensation.**—With compound locomotives, it is possible to use pressures of 200 pounds or more, and to reduce both the cylinder condensation and the exhaust pressure; hence, greater economy can be obtained with compounds by using steam of higher pressure. Condensation is less, for the reason that the steam is expanded in two cylinders instead of in one, as in the simple engine; hence, the range of pressure and consequent range of temperature in either cylinder of the compound is very much less than it is in the cylinder of a simple engine. The amount of condensation that will take place depends on the difference between the temperature of the cylinder walls at admission and the temperature of the entering steam; and, since this difference is very much less in the compound than in the simple engine,

it follows that the condensation will be less in the compound. With a cross-over compound, the steam in passing from one cylinder to the other goes through the receiver, which is enclosed in the smoke arch, and the high temperature there tends to reheat the steam.

**9. Increased Expansion.**—The reduction in the exhaust pressure is brought about by expanding the steam considerably more than is done in the simple engine. The exhaust pressure of a simple engine using high-pressure steam is so high as to be very wasteful, whereas the exhaust pressure of a compound is no higher than is necessary to maintain the proper draft through the fire. The high exhaust pressure of the simple engine represents a waste of considerable power; the compound, on the other hand, by expanding the steam to a much lower pressure, saves a great deal of power that is wasted in the simple engine; therefore, it can do the work with less steam and will require less coal and water. The compound engine is more economical when the proper rate of expansion is being obtained; therefore, it is not economical at a very short cut-off, as the low-pressure cylinder does not do its proper share of the work.

**10. Slower Rate of Combustion.**—Assume two locomotives, one simple and the other compound, but both of the same size and type: The boilers will have equal heating and grate surfaces, and should therefore be equally economical for like rates of combustion; but owing to its increased rate of expansion and decreased cylinder condensation, the compound engine requires less steam than the simple engine, and its rate of combustion will be less. This not only means that the compound locomotive requires less coal, but that the coal used is burned at a slower, and consequently more economical, rate. A number of experiments conducted by Prof. W. F. M. Goss, of Purdue University, demonstrated that, when coal (Brazil block) was burned at the rate of 50 pounds per square foot of grate surface per hour, $8\frac{1}{2}$ pounds of water was evaporated for each pound of coal used; while, when the rate was increased to 180 pounds of

coal per square foot of grate, only $5\frac{1}{2}$ pounds of water was evaporated per pound of coal—a loss of about 35.3 per cent. Strictly speaking, the above relationship between the water evaporated and the coal burned applies to the boiler from which the relationship was determined, but all locomotive boilers may be expected to give the same general result; that is, the values may vary some, but they will be in the same general proportion.

**11.** The milder exhaust of the compound is in several respects more advantageous than the stronger exhaust of a simple locomotive. In the first place, the heating surfaces of the boiler absorb heat from the gaseous products of combustion as they pass on their way to the stack, and the slower the velocity of the gases, the greater will be the amount of heat surrendered, and the less will be the amount carried away as waste heat; hence, the milder exhaust and slower rate of combustion of the compound cause more of the heat of the gases to be delivered to the water, and less to be lost in the waste gases. Also, a thinner fire can be carried, which still further insures better combustion.

There is still another advantage, in that less unconsumed fuel is carried through the tubes into the smokebox, and thence out of the stack. This not only represents an actual saving in fuel, but also greatly diminishes the chances of fires along the roadway, due to live sparks alighting on inflammable material. In some experiments conducted by Professor Goss, it was found that, while the rate of combustion for a simple locomotive varied from 64 to 241 pounds of coal per square foot of grate surface, the spark losses ranged between 4.3 and 15.5 per cent. of the coal fired.

---

## PROMINENT TYPES

**12. The Different Systems.**—There are only two types of compounds that are used to any extent in this country; namely, the four-cylinder compound and the two-cylinder compound. Of the four-cylinder compounds there are three systems—namely, the *Baldwin* (*Vauclain*), the *balanced*, and

the *tandem*. The principal two-cylinder types in use are the *Richmond*, the *Schenectady*, and the *Pittsburg;* there is also a *Baldwin two-cylinder type*.

---

### FOUR-CYLINDER COMPOUNDS

**13.** The **Baldwin (Vauclain) compound** is known as the Vauclain compound after its inventor, Mr. Samuel M. Vauclain. It has two cylinders—one low pressure and one high pressure—on each side, arranged one above the other in the same vertical plane, and is called a non-receiver, or continuous-expansion, compound, from the fact that each high-pressure cylinder exhausts directly into the low-pressure cylinder that is on the same side of this locomotive. Steam from the high-pressure cylinder cannot exhaust to the stack direct, but must pass through the low-pressure cylinder first. The area of the low-pressure piston is about three times that of the high-pressure piston. Both piston rods are coupled to the same crosshead, one above the other, with the main-rod connection between the piston rods.

The **balanced type** of compound has two cylinders—one low pressure and one high pressure—on each side; the high pressure piston is coupled to a crank in the forward driving axle and the low-pressure piston is coupled to a crankpin in the driving wheel.

The **tandem compound** has two cylinders—one low pressure and one high pressure—on each side; the high-pressure cylinder is in line with and ahead of the low-pressure cylinder. The steam passes from the boiler to the steam chest of the high-pressure cylinder; after expanding in this cylinder it passes into the low-pressure cylinder; it is a non-receiver type, the steam chests of both cylinders being continuous or directly connected with each other.

The valves for the high-pressure and low-pressure cylinders in each case are connected to the same valve rod and move at the same time.

Both the balanced and the tandem four-cylinder compounds have a *starting valve* to admit live steam into the low-pressure cylinders to increase the tractive power of the

locomotive. When working compound, no steam passes into the low-pressure cylinder until the high-pressure piston has made a stroke and discharged its steam, in which case the low-pressure piston will not exert any power to move the engine until the engine has made part of its first revolution. To allow the low pressure to assist in starting the engine, live steam is admitted direct into the low-pressure cylinder and presses against an area three times as large as if working against the high-pressure piston only. Also, when the engine is moving, the pressure against the large low-pressure piston can be increased by admitting steam through the starting valve; this increases the tractive power.

---

### TWO CYLINDER COMPOUNDS

**14. Baldwin Two-Cylinder.**—This compound is provided with an intercepting and a separate exhaust valve, and is of the cross-compound automatic type.

**15. Richmond (Mellin).**—This compound was invented by Mr. C. J. Mellin. It has two cylinders, one on either side, the exhaust passage from the high-pressure cylinder being connected with the steamway to the low-pressure cylinder by means of a large reservoir or receiver placed in the smokebox. In other words, the high-pressure exhaust steam must cross over from one side to the other in passing from the high-pressure into the low-pressure cylinder; hence, this type is often called a *cross-over*, or *cross-compound*, type. It is also often called a *receiver* compound to distinguish it from types that have no receiver. It has an *intercepting valve* in the cylinder saddle, and is provided with a separate exhaust passage for the high-pressure cylinder exhaust, for use during the time the engine is working simple. It is known as an *automatic* system for the reason that, when starting compound without any pressure in the receiver, the intercepting and reducing valves automatically move to simple position for a revolution or two, or until the receiver is charged to pressure, when they automatically return to compound position. The intercepting valve can be held in simple position at any

time by the engineer. The area of the low-pressure piston is about two and one-half times that of the high-pressure piston.

The capacity of the receiver used in cross-compound locomotives varies with the make of the locomotive. It is based on the capacity of the high-pressure cylinder, and in some makes it has from two to three times the capacity of that cylinder, while in others it has from three to four times the capacity. Generally, large receivers give less variation in receiver pressure, and hence are conducive to economy; but for good working, the receiver capacity should not be less than twice the capacity of the high-pressure cylinder. While passing through the receiver, the steam is reheated to a greater or less degree depending on the length of time that it remains in the receiver and on the temperature in the smokebox.

**16. Schenectady (Pitkin).**—The Schenectady compound, invented by Mr. A. J. Pitkin, is also of the two-cylinder cross-compound type; it has an intercepting valve, and is provided with a separate exhaust port for the exhaust of the high-pressure steam during the time that the engine is working simple. The Schenectady, like the Richmond, is automatic in its action—starting in simple position and changing to compound. Its low-pressure piston has about two and one-half-times the area of the high-pressure piston.

**17. Pittsburg (Colvin).**—This compound is also of the cross-compound type, and has an intercepting valve and a separate exhaust passage for the high-pressure exhaust. It is strictly non-automatic, however; that is, the intercepting valve must be moved from one position to another by the engineer.

**18. Cross-Compounds Working Simple.**—When a cross-compound is worked simple, the live steam after doing its work in the high-pressure cylinder passes through the intercepting valve, which is in simple position, and direct to the stack, instead of to the receiver and into the low-pressure steam chest. This does away with the back pressure

against the high-pressure piston, which amounts to 40 per cent. when working compound. On the low-pressure side, live steam is admitted direct to the low-pressure steam chest, so that the low-pressure piston is at work at once, instead of waiting until the high-pressure cylinder has discharged enough steam into the receiver to give a working pressure against the low-pressure piston. The live steam admitted to the low-pressure steam chest passes through a *reducing valve* that automatically reduces the pressure to about 40 per cent. of the boiler pressure, which equalizes the work done by each side of the engine. The reducing valve admits live steam to the low-pressure side until the pressure reaches the proper amount; the valve then cuts off the supply of steam so that it does not increase above this amount.

If, when about to start a cross-compound locomotive, the high-pressure side were on or near the dead center, the low-pressure piston would have to do the work. For that reason the intercepting and reducing valves are necessary to close the connection between the low-pressure steam chest and the high-pressure cylinder, to open the direct exhaust from the high-pressure cylinder to the atmosphere, and to admit at a reduced pressure live steam to the low-pressure side. The tractive power of the engine can also be increased by these valves when operating the engine as a simple one. For that reason the rail should be sanded when starting a heavy train with the engine in simple position.

When lubricating the cylinders of a compound engine more oil should be fed to the high-pressure cylinder when working steam than to the low-pressure cylinder, as some of the oil from the high-pressure cylinder passes over with the steam. When drifting, the low-pressure cylinder requires more oil, both because it is the larger and because hot gases from the front end are apt to get in at the exhaust passage. If no provision is made for oiling the low-pressure cylinder separately, oil can be put in at the relief valves.

If a cross-compound will not start when given steam with the high-pressure side on the center, the intercepting and reducing valves are stuck fast in compound position so that

no steam will go to the low-pressure side to start the engine. In this case, the intercepting valve must be forced to simple position by hand. It should be kept lubricated and free of grit. Working muddy water over from the boiler will usually stick the intercepting valve of an automatic compound.

## BALDWIN (VAUCLAIN) SYSTEM

### DESCRIPTION, OPERATION, AND OPERATING

#### DESCRIPTION

**19. General Arrangement.**—The Vauclain compound locomotive consists of two compound engines, one on either side, the two cylinders *A*, *B*, the valve chamber *C*, and a half saddle being cast in one piece, Figs. 1 and 2. The arrangement of the cylinders and valve bush in the saddle depends on the size of the driving wheels, as with small wheels the

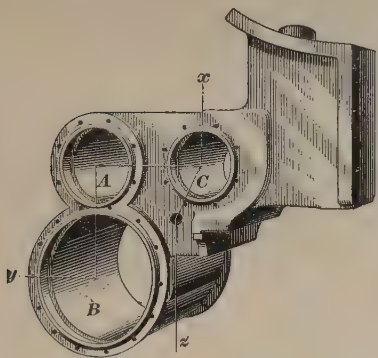



FIG. 1

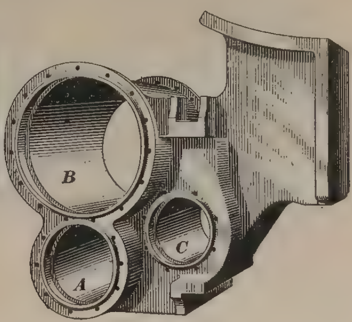



FIG. 2

large, low-pressure cylinder will strike the ground; in such cases, this cylinder is placed above the other. In eight- and ten-wheeled locomotives having large drivers the arrangement used is that shown in Fig. 1; in mogul, consolidation, and decapod locomotives, the arrangement is that shown in Fig. 2. It will be observed that, whatever the arrangement,

one cylinder is directly above the other—their center lines being in the same vertical plane—and the valve chamber *C*, which takes the place of the steam chest, is situated between the cylinders and the smokebox, as close to the cylinders as convenient, in order that the steamways leading to the cylinders may be as short as possible. The smaller cylinder *A* is called the high-pressure cylinder, for the reason that steam is admitted to it directly from the boiler and at nearly boiler

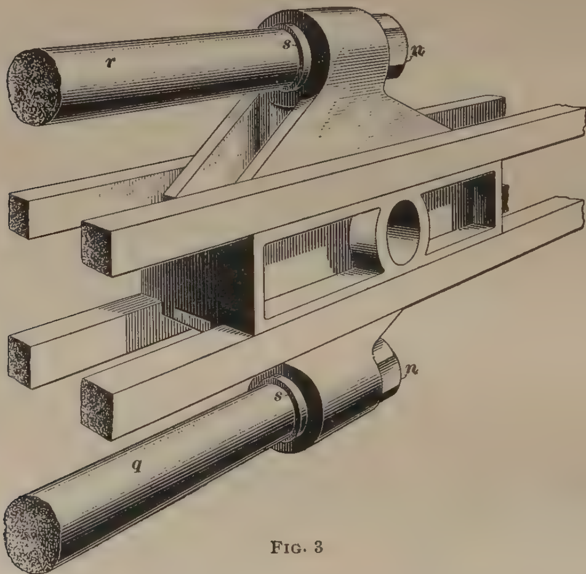



FIG. 3

pressure. The steam is allowed to expand in this cylinder, thereby having its pressure reduced to a greater or less extent, and is then discharged into the larger cylinder *B*, called the low-pressure cylinder, on account of its being operated by steam of much lower pressure than that used in the cylinder *A*. The steam is expanded still farther in the low-pressure cylinder, and is then discharged into the atmosphere through the exhaust in the usual manner.

**20.** The pistons that operate within the two cylinders are connected to the same crosshead, as shown in Fig. 3.

The piston rods *r*, *g* are made of equal diameter, and with a shoulder *s* on the crosshead end to prevent the rod from being forced into the crosshead; also, by the use of this shoulder, the end that enters the crosshead can be made of equal diameter with the body of the rod, thus greatly strengthening the rod at the crosshead. The holes made in the crosshead to receive the piston-rod ends are tapered to insure a perfect fit, and are bored in such a manner as to insure the rods being perfectly parallel to each other. The rods are secured to the crosshead by means of large nuts *n*, *n*, and these, in turn, are prevented from coming loose by taper keys through the ends of the rods.

**21. The Piston Valves.**—The valve used to distribute the steam to the cylinders is of the piston type, and works within the valve chamber *C*. In reality, it is a double valve, and, by its peculiar construction (being hollow), is enabled to do the work of two valves; that is, it controls the admission of steam to, and the exhaust of steam from, both the high- and the low-pressure cylinders. A perspective view of

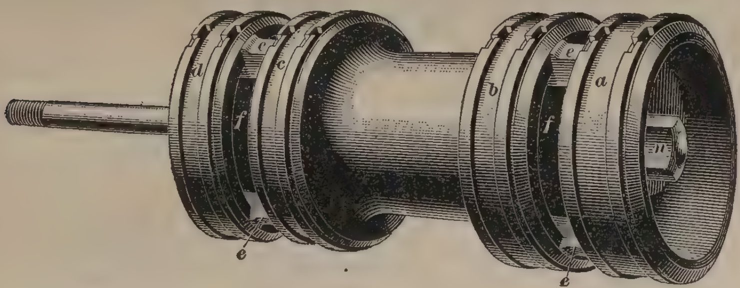



FIG. 4

this **piston valve** is given in Fig. 4, while Fig. 5 is a cross-sectional view of the valve in the valve chamber, showing the interior of the valve and the cavities in the casting surrounding the valve bush. The valve is fitted with two pair of cast-iron packing rings at either end, which constitute its edges. The rings on the outer heads *a*, *d* control the admission of steam to, and the exhaust of steam from, the high-pressure cylinder, while the rings on the heads *b*, *c* perform

the same duties for the low-pressure cylinder. The end heads *a*, *d*, Fig. 5, are made solid, while the inner heads *b*, *c*, together with that part of the valve between them, are hollow and are secured to the outer heads by several ribs *e*.

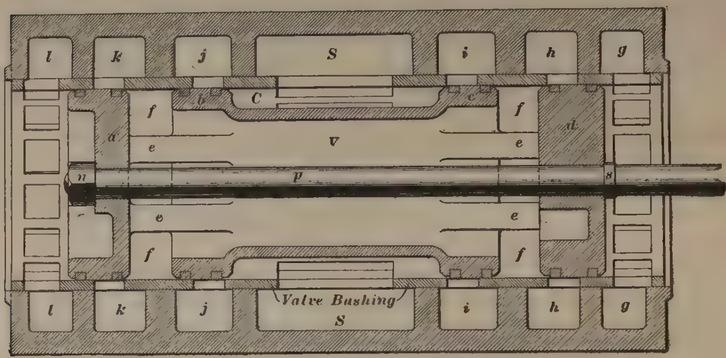



FIG. 5

The slots *f*, *f* between the heads *a*, *b* and *c*, *d* are thus connected through the inner cavity of the valve *V*. The valve stem *p* passes through the valve and is held in position by the shoulder *s* and the nut *n*.

22. **Movement of Piston Valve.**—When the cylinders are arranged, Fig. 1, with the low-pressure cylinder underneath, a **rocker** is used to transmit the motion of the eccentrics to the valve; but when the low-pressure cylinder

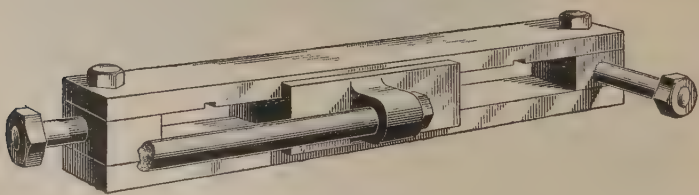


FIG. 6

is on top, as in Fig. 2, the upper bar of the frame prevents the use of a rocker, and the valve gear must be made direct-acting. The method used to transmit the motion of the eccentrics to the valve, when a double front rail is used,

consists of a small crosshead and guides, Fig. 6, together with a valve stem that connects the valve with the crosshead, and a valve rod to connect the crosshead with the link. A later design employs a rocker-arm that does not reverse the motion of the valve in relation to the link block, and uses a

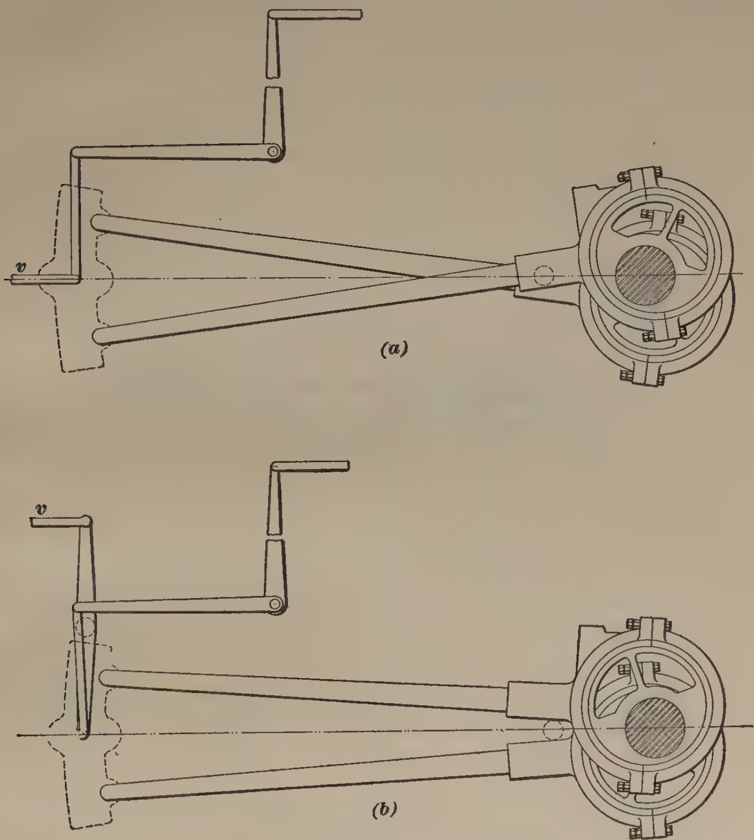



FIG. 7

transmission bar. When a direct-acting valve mechanism is used, the eccentrics must be placed on the driving axle as shown in Fig. 7 (*a*), while view (*b*) shows the position of the eccentrics on the driving axle relative to the main pin when an indirect motion is used. It will be noticed, view (*a*),

that with a direct motion the forward-motion eccentric is below the axle so that the eccentric rods are crossed when the engine is on the forward center. With an indirect motion, however, the rods are not crossed.

**23. Valve Bushing.**—In order that the steam may be properly distributed to the steam cylinders, it is necessary that the port openings in the steam chest (valve chamber *C*) be machined accurately to the required sizes. But, since it would be both difficult and costly to machine the passages in the cylinder castings themselves, they are made larger than required for the finished ports, and the steam chest is bored out sufficiently larger in diameter than the diameter of the

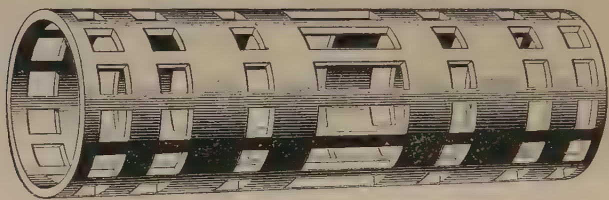
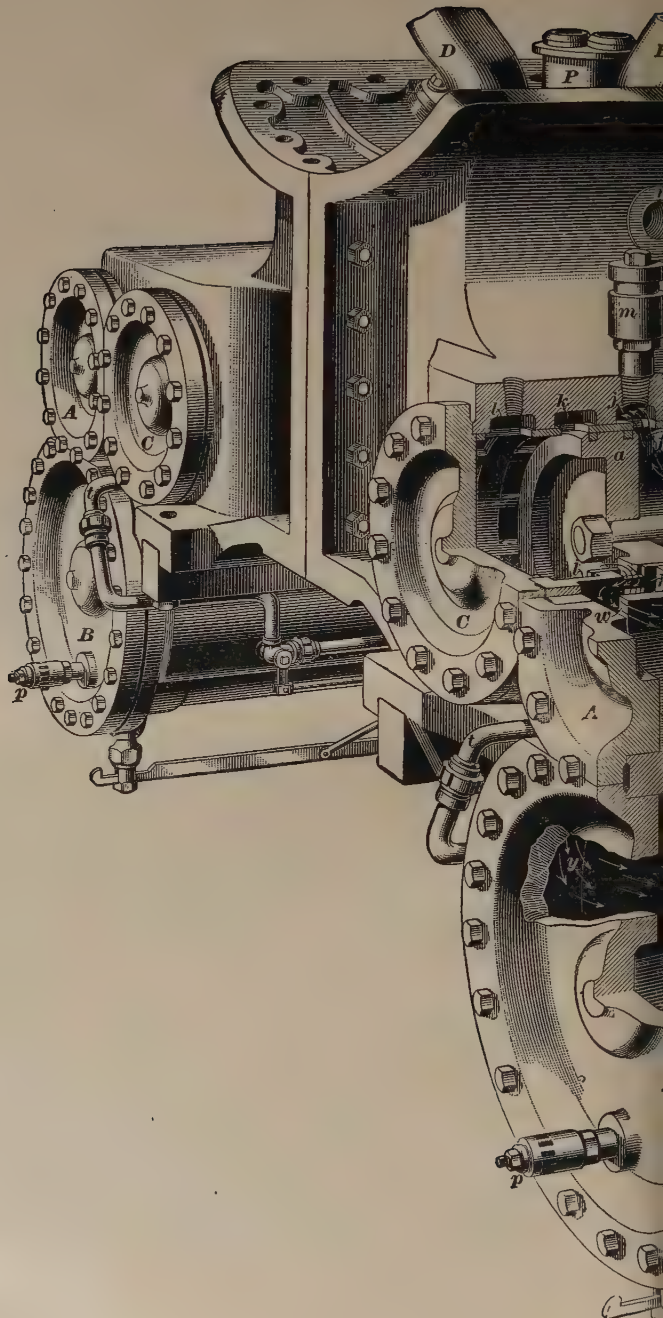
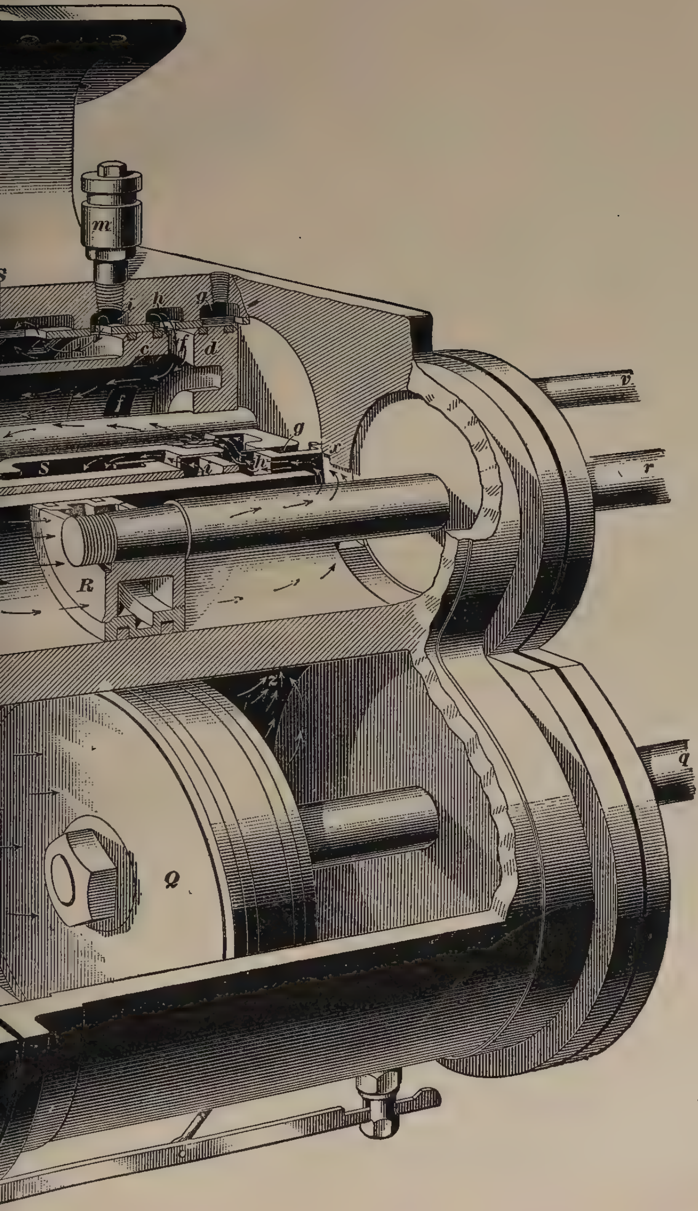


FIG. 8

valve to permit the use of a bushing similar to that shown in Fig. 8. This bushing is made of hard cast iron, and is forced into the steam chest under pressure, so as to make steam-tight joints between the ports, thus preventing leakage of steam from one steam passage to another. All the ports in the bushing can be machined with great accuracy, so that a uniform distribution of steam is made to the cylinders under all conditions.

**24. Steam Chest.**—In Fig. 9 is shown a perspective view of the cylinders and saddle of a Vauclain compound, in which a section through the steam chest and high- and low-pressure cylinders is taken on the dotted lines $x, y$, Fig. 1, the upper part being removed to show the interior of the steam chest and cylinders. $V$ is the piston valve, $v$ its stem, $R$ and $Q$ the high-pressure and low-pressure pistons, respectively, and $r$ and $q$ their rods. As will be seen, there are a number


D
P
m
l
k
j
a
A
C
B
t
p
C
w
A
t
y
p




§ 20

of chambers cast in the saddle that extend completely around the valve bushing. The steam pipe $E$ connects with a steamway in the cylinder saddle that divides into two branches; the end of one branch forms chamber $g$, while the end of the other forms chamber $l$, both of which surround the valve bushing. Steam pipe $D$ supplies steam to the right-hand cylinders. Chamber $k$ is the steam-chest end of the steam passage $w$ that leads to the front end of the high-pressure cylinder $A$, while chamber $h$ is the end of the steam passage $x$ that leads to the back end of the cylinder. The chambers $j$, $i$ are the steam-chest ends of the steam passages $y$, $z$ that lead to the front and back ends, respectively, of the low-pressure cylinder $B$. Chamber $S$ in the cylinder saddle forms the steam-chest end of the exhaust steamway that leads to, and connects with, the exhaust pipes $P$. It will thus be seen that steam from the boiler enters the steam chest through the end cavities $g$, $l$, so that, when the throttle is open, the two ends of the steam chest are filled with steam. Also, it will be seen that the steam must pass from the steam chest through chamber $k$ or chamber $h$ in order to get into the front or back end of the high-pressure cylinder, respectively. Also, for steam to enter the front or back end of the low-pressure cylinder, it must pass through chamber $j$ or chamber $i$, respectively. Steam, in exhausting to the atmosphere from the low-pressure cylinder, must pass through the cavity $S$. Two relief valves $m$, $m$ are screwed into holes that lead to the passages $j$, $i$, and another valve is screwed into a hole $n$ leading to the steamway in the cylinder saddle. The arrangement of the cylinders, steamways, and cavities in relation to the steam valve will be more clearly seen by referring to Fig. 10.

## OPERATION

**25. Forward Stroke.**—The views of the steam chest and cylinders in Figs. 10 and 11 are not true sectional views, but are conventional views made up for the purpose of showing the relation of the high- and low-pressure cylinders to

the steam valve, as well as the relation of the chambers $h, i, j$, etc. to the steamways $w, x, y$, and $z$ that lead to the ends of the two cylinders. Also, the operation of the engine can be more clearly shown by means of these figures.

Suppose the engine to have been working, so that both cylinders are working steam; then the operation for the forward stroke, Fig. 10, will be as follows: With the valve in the position shown, steam from the steam chest enters the back end of the high-pressure cylinder $A$ through chamber $h$ and the steamway $x$, as indicated by the arrows, forcing the piston toward the front end of the cylinder. The steam in the front end of the high-pressure cylinder is exhausting through the steamway $w$, chamber $k$, cavity of valve $V$, chamber $i$, and steamway $z$, into the back end of the low-pressure cylinder $B$, as indicated by the arrows, thus forcing the low-pressure piston toward the front end of its cylinder also. The exhaust steam in the front end of the low-pressure cylinder is exhausting to the atmosphere through the passage $y$, chamber $j$, cavity of valve $V$, and the exhaust port $S$, as indicated.

**26. Backward Stroke.**—In the backward stroke of the pistons, Fig. 11, the valve is admitting steam to the front end of the high-pressure cylinder, as shown, while the steam in the back end of the high-pressure cylinder is exhausting into the forward end of the low-pressure cylinder; hence, both pistons are being forced toward the back end of their cylinders. The exhaust steam in the back end of the low-pressure cylinder is passing through the steamway $z$, chamber $i$, and cavity of valve, into the exhaust passage $S$. By comparing Figs. 10 and 11, it will be seen that the high-pressure cylinder receives the steam directly from the boiler through the steam chest, while the low-pressure cylinder receives its supply of steam directly from the exhaust side of the high-pressure cylinder. In other words, the high-pressure cylinder receives steam from the boiler for a certain part of the stroke, allows it to expand practically for the remainder of the stroke, and then discharges it into

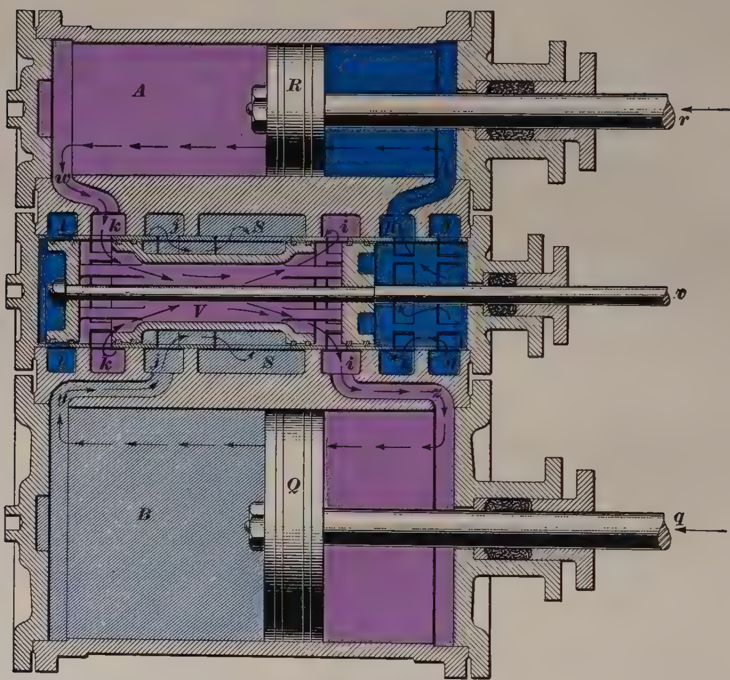


Fig. 10

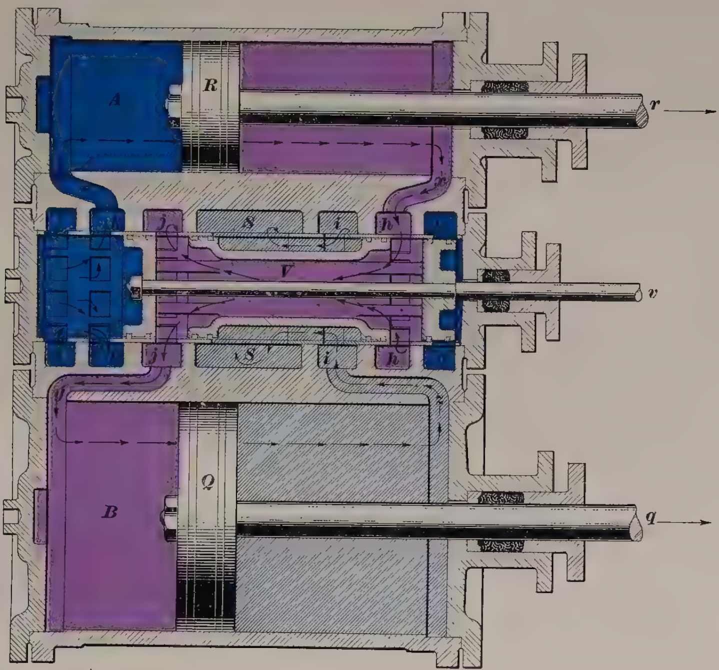



FIG. 11

the low-pressure cylinder, where it is still further expanded, after which it is discharged through the exhaust pipes in the usual manner.

It is obvious that if this compound locomotive is started from a state of rest while working compound, no steam can enter the low-pressure cylinders until after part of a revolution has been made by the drivers; hence, in that case, the duty of giving the train its first motion would fall entirely on the high-pressure cylinders, while the low-pressure cylinders would lend absolutely no assistance at the very time their help was most needed. This would not only greatly reduce

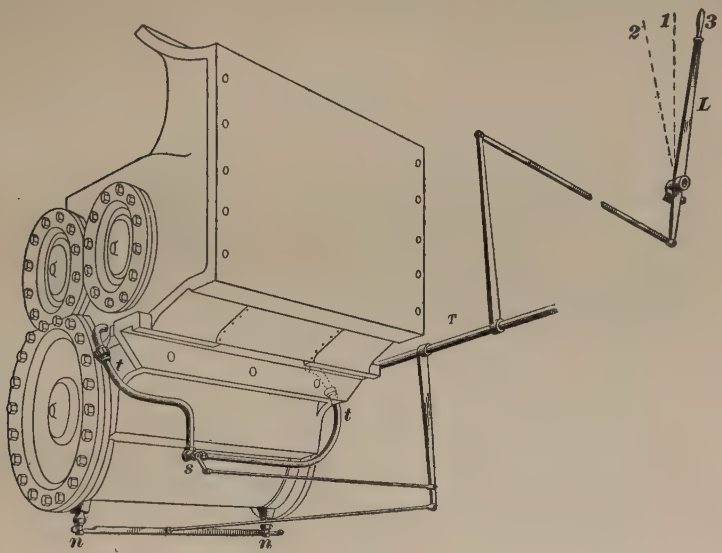



FIG. 12

the starting power of the locomotive, but, with a heavy train, it would subject certain parts of the driving gear to such strains as would probably lead to breakdowns. To overcome this difficulty, it was found necessary to devise a means of admitting steam from the boiler directly into both the low-pressure and the high-pressure cylinders while starting the train; and the device by means of which this has been accomplished is known as the **starting valve.**

**27. General Arrangement of Starting-Valve Gear.** The arrangement of the starting-valve gear is shown in Fig. 12. The starting valve *s* is connected by the pipe *t* to the steamways *h*, *k*, Fig. 11, that lead to the opposite ends of the high-pressure cylinder. This valve is merely a by-pass valve, and is operated by the same lever *L* in the cab that operates the cylinder cocks *n*. The later arrangement of the starting valve, Fig. 14 (*b*), places it above the steam chest, in which case it has a separate lever in the cab for operating it, and is not connected with the cylinder cocks. This starting valve is simply a plain plug cock in a straight pipe, and does not have the cylinder cocks combined with it as in the old starting valve.

**28. Construction of Starting Valve.**—Sectional views of the starting valve are shown in Fig. 13 (*a*), (*b*), and (*c*). One end of the pipe *t* connects with the top opening *W*, the other end connects with the side opening *U*, while the small opening *N* on the bottom leads to the atmosphere. When the handle *H* is pointing downwards, as in view (*a*), the valve is closed, since the plug of the valve closes all the openings. When the handle is moved to the forward position, view (*b*), the passage *3*, through the plug of the valve, connects the port opening *N* with port *W*, while the passage *4* connects with port *U*; hence, there is a direct opening to the atmosphere through the pipe *5*, while at the same time there is direct passage between the ports *W* and *U* through the passages *3* and *4*. Thus, when in this position, the valve not only acts as a by-pass valve, but also as a cylinder cock for the high-pressure cylinder, since steam can pass from one pipe *t* to the other through the passages *3* and *4* in the plug of the valve, or from either pipe to the atmosphere through port *N* and pipe *5*.

When the handle *H* of the valve is in the position indicated in view (*c*), the passage *4* in the plug connects with the port *W*, while the passage *3* connects with the opening *U*, and the port *N* leading to the atmosphere is blanked; hence, in this position the valve acts simply as a by-pass valve, allowing

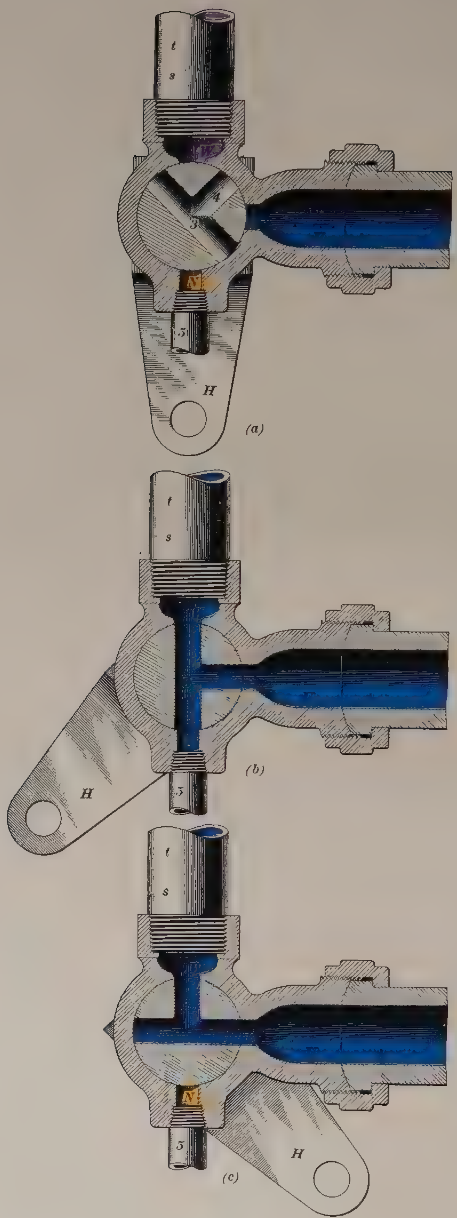



FIG. 13

§ 20 13180

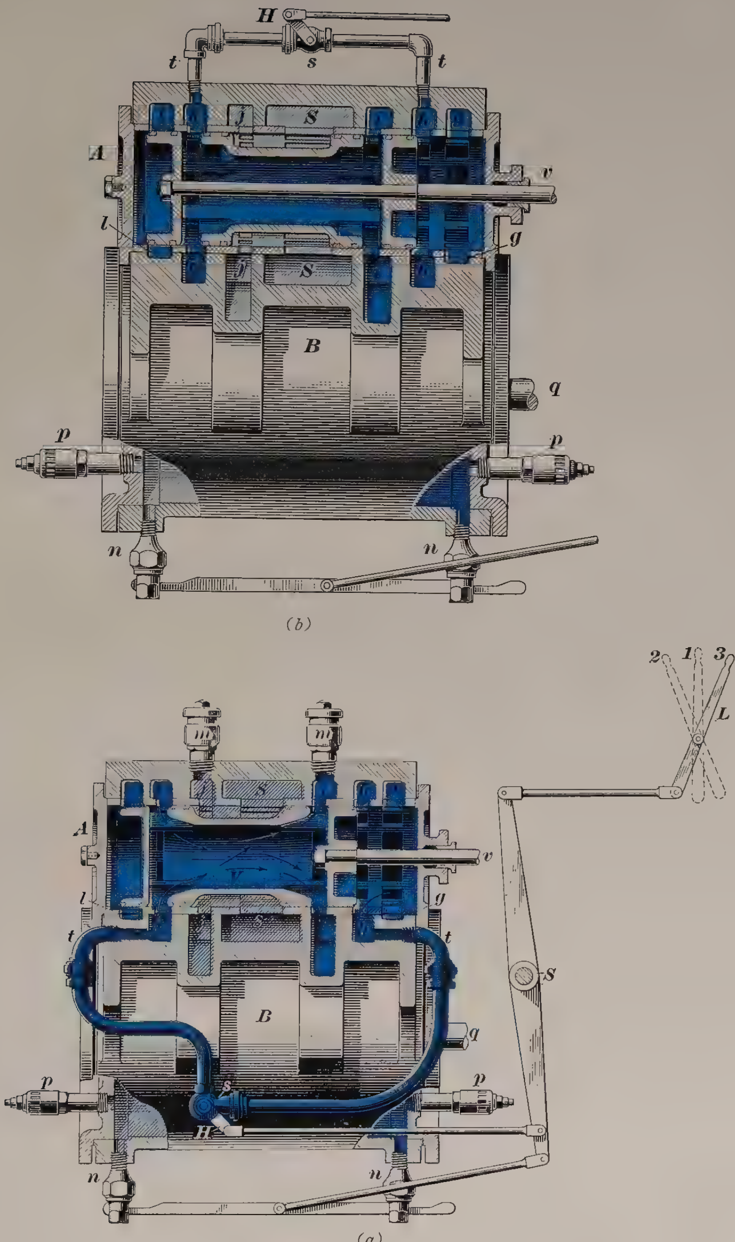



FIG. 14

§ 20 13180

steam to pass through it and pipe $t$ in either direction, but preventing any discharge of steam to the atmosphere through the port $N$. With the other type of starting valve, the opening at port $N$ is omitted and the valve is simply a by-pass valve with but two positions.

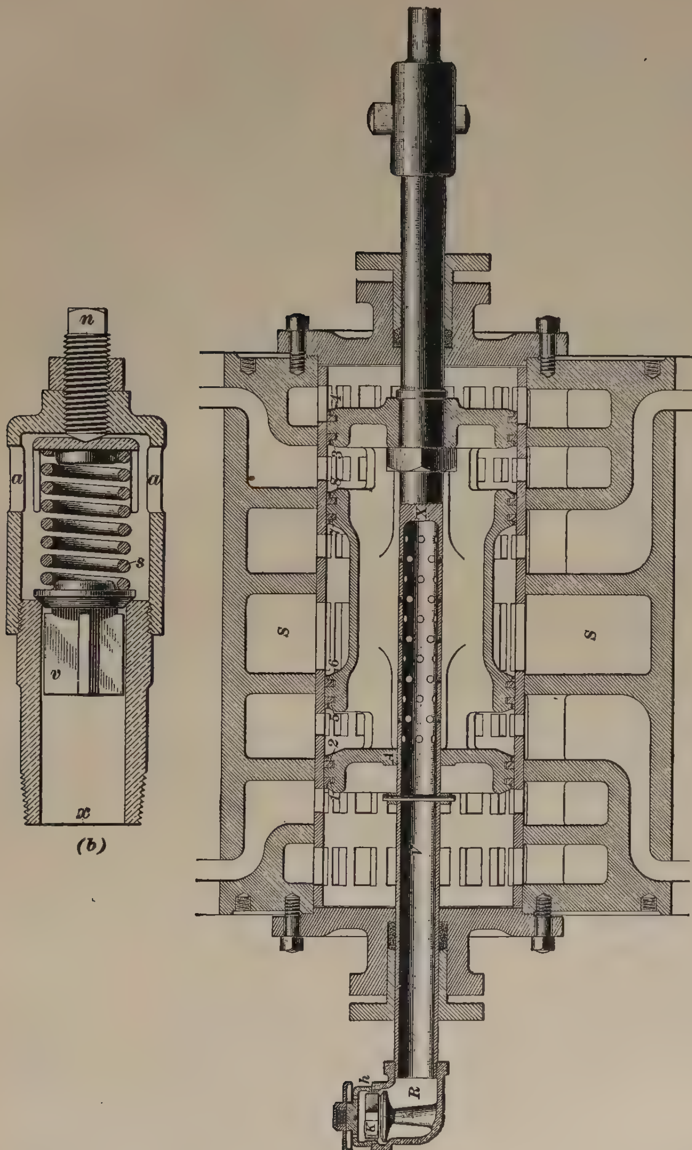
**29. Operation of Starting Gear.**—The operation of the starting gear can best be explained by referring to Fig. 14. If the cylinder casting, Fig. 1, were cut through on the line $x z$, and the right-hand portion were removed, the remainder would show a section somewhat as in Fig. 14. The high-pressure cylinder $A$ cannot be seen, as it is on the far side of the steam chest, but the back side of the low-pressure cylinder $B$ can be seen. It will be observed that one end of the pipe $t$ is screwed into a hole that is drilled into chamber $k$, which is one end of the steamway that leads to the front end of the high-pressure cylinder, and which opens also into the front end of the steam chest through the ports in the valve bushing. The other end of the pipe $t$ is screwed into a hole that is drilled into chamber $h$, thus making direct connection between this end of the pipe, the back end of the high-pressure cylinder, and the back end of the steam chest. Thus, the two ends of the high-pressure cylinder can be connected through the starting valve. The handle $H$ of the starting valve is connected to the same lever as is the mechanism that operates the cylinder cocks, and when the lever $L$ is in its middle position *1*, the starting valve is closed. When the engine is operated with the starting valve in this position, the engine is said to be working *compound*, since no **live steam*** enters the low-pressure cylinder. If the lever $L$ is moved forwards to position *2*, the handle $H$ will be moved forwards also, and the starting valve and the cylinder cocks to both the high- and the low-pressure cylinders will be open, and live steam can pass to the low-pressure cylinder through the starting valve, as indicated by the arrows. The engine is then said to be working *simple*, since live steam enters the low-pressure cylinders. If lever $L$ is moved to position *3*, the

* Steam direct from the boiler.

handle will be moved to its back position; in this position, the cylinder cocks will be closed, but steam can still pass from the steam chest and high-pressure cylinder to the corresponding end of the low-pressure cylinder, as indicated by the arrows. For example, in the figure, the valve is forwards, and is admitting steam into the back end of the high-pressure cylinder through chamber *h*; at the same time, steam passes from chamber *h* through the first part of pipe *t*, the starting valve *s*, and the second part of pipe *t*, into chamber *k*, and thence through the valve *V* and chamber *i* to the back end of the low-pressure cylinder, as indicated by the arrows. In this position of the starting valve, also, the engine is said to be working simple.

It should be noted that, with either arrangement of starting valve, since live steam enters the cavity *k*, it is free to fill the front end of the high-pressure cylinder and to act therefore as back pressure on the high-pressure piston. This, of course, reduces considerably the force with which the high-pressure piston is moved forwards, but this is more than compensated for by the increase of total effective force on the low-pressure piston, due to its greater area. The latter has about three times the area of the high-pressure piston; hence, for every pound of force exerted as back pressure on the high-pressure piston, the live steam exerts an effective force of 3 pounds on the low-pressure piston, and the power of the engine is correspondingly increased. However, the starting valve should not be used except when starting a heavy train or when in danger of stalling on a grade.

**30. Relief Valves.**—It is usual to supply the cylinders of locomotives with **relief, or vacuum, valves,** the duty of which is to prevent the formation of a vacuum in the cylinders, which would draw in hot gases and cinders. Vauclain compounds are supplied with relief valves also, although they are situated differently from those on simple engines. As already remarked, a relief valve is screwed into the hole *n* (see Fig. 9) that leads to the steamway in the cylinder saddle; hence, if a vacuum tends to form in




(b)

(a)

Fig. 15

the steamway, or in the high-pressure steam chest or cylinder, this valve will admit air and thus prevent it. Also, the relief valves *m*, Figs. 9 and 14, are screwed into holes that lead to the cavities *j* and *i*, and help prevent the formation of a vacuum in the low-pressure cylinder.

A relief valve to supply air to the low-pressure cylinder when drifting is shown in Fig. 15 (*a*). The valve rod *V*, which extends through the front head of the steam chest and is provided with suitable packing, is hollow from the point *X* to the front end where the relief valve *R* is attached. A number of holes are drilled through the rod, as shown, which establish communication between the inside of the piston valve and the atmosphere when the valve *K* is down off its seat *h*.

The space inside the piston is so connected to the low-pressure cylinder that when drifting with steam shut off, the air from the atmosphere can flow in and relieve the partial vacuum caused by the movement of the low-pressure piston. When the engine is working steam the hollow valve rod fills with steam, which closes the valve *K*. By extending the valve rod in front, it acts as a support to the piston valve, and thus tends to reduce the wear on the bottom of the valve and bushing.

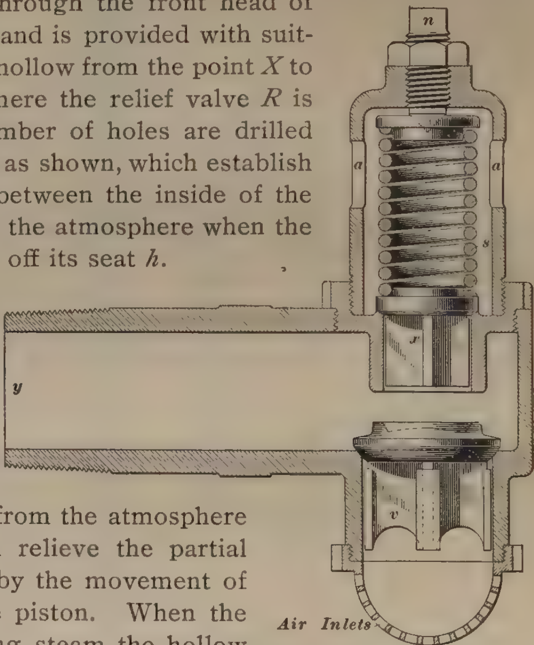


FIG. 16

The low-pressure cylinders are also equipped with water-relief valves *p*, *p*, Fig. 14, attached to the front and back cylinder heads, to prevent the breaking of a cylinder head in case water should get into the cylinder. These water valves also act as safety valves to prevent excessive pressure of any kind, and they can be adjusted, by means of an adjusting

screw, to open at any desired pressure. A sectional view of the water valve is given in Fig. 15 (*b*). The end *x* screws into the steam chest, and when the pressure on the valve *v* becomes great enough to compress the spring *s*, the valve will open and allow the excess pressure to escape to the atmosphere through the openings *a*, *a*. The tension of the spring *s* can be regulated by means of the adjusting screw *n*.

When an engine has the low-pressure cylinder on top, as in Fig. 2, a different arrangement must be adopted on the low-pressure cylinders, and a combined pressure and vacuum relief valve, similar to that shown in Fig. 16, is used in each head of the low-pressure cylinder. If a vacuum tends to form in the cylinder, air enters the valve through the air inlets at the bottom, and, raising the valve *v*, passes on to the cylinder through *y*. Any excessive pressure in the cylinder will raise the valve *x* against the action of the spring and allow the excess of pressure to escape through the openings *a*, *a*. The tension of the spring *s* can be regulated by means of the adjusting screw *n*.

---

## OPERATING

**31. General Considerations.**—Before an engineer can hope to become a successful runner of compound locomotives, he must learn, first of all, to handle the reverse lever properly. The quadrant of the reverse lever is usually so made that it is impossible to cut off steam in the high-pressure cylinder at less than half stroke, and the reverse lever can be safely carried in any notch, from the corner to the half-stroke notch, without injury to the fire. This is due to the milder exhaust of the compound, which thus enables the fireman to carry a lighter fire than he would with a simple engine.

**32. Handling Cylinder-Cock Lever.**—It is a good rule, when handling compounds, to always open the cylinder cocks in starting the locomotive from a state of rest, so as to permit the water of condensation to escape from the cylinders. Of course, by opening the cylinder cocks, the starting

valve is opened, and live steam is admitted to the low-pressure cylinder, causing the train to start quickly and smoothly. Sometimes, however, as when in a crowded station, it is undesirable to open the cylinder cocks, in which event the engineer should move the cylinder-cock lever backwards to the position *3*, Figs. 13 (*c*) and 14 (*a*), for admitting steam to the low-pressure cylinder without opening the cylinder cocks. If the cylinder cocks are opened in starting, they should be closed as soon as the cylinders are free of water, and, whatever the position of the cylinder-cock lever, it must be moved to compound position (middle position) before the reverse lever is moved from the corner. If it is necessary to open the cylinder cocks when at full speed, in order to relieve the cylinders of water, it may be done without moving the reverse lever from its position, since at high speeds the steam will not pass through the starting valves quickly enough to give an excessive pressure in the large cylinders. At slow speeds, however, the lever should always be in the corner during the time the starting valve is open. If it is necessary to open the cylinder cocks at slow speeds, first drop the reverse lever into the corner and let it remain there until the cylinder-cock lever has been moved to its middle position again. A locomotive will not make as good time with the starting valve open as with it closed, besides using a great deal more coal and water; hence, an engineer should run with the starting valve open only when starting a heavy train or when in danger of stalling.

**33. Handling Reverse Lever.**—Experiment and also general experience show that the simple engine is most economical when cutting off at about one-quarter stroke; the most economical point of cut-off for the compound engine, on the other hand, is about five-eighths stroke. Experiments also show that, as the reverse lever of the simple engine is notched toward the corner, the amount of water used per horsepower per hour increases rapidly; whereas, the amount of water used by the compound increases at a much slower rate. This peculiarity of the two types of locomotives is

quite noticeable, especially to an engineer that has handled both types. The rate for the compound increases quite rapidly, however, when it is being run with the starting valve open; hence, for the sake of economy, this valve should be used as seldom as possible. If, during the run, the locomotive is called on for an extra effort that tends to slow down the speed of the train, the reverse lever should be dropped—a notch or two at a time—soon enough to maintain the speed as nearly as possible. In this way less coal and water will be used than if the train is allowed to slow down considerably before the lever is dropped, and then has to be brought up to speed again. Also, the unequal strain and wear on the crossheads, guides, and piston rods will be much less, when working in the running cut-off, than when using a very long cut-off or the starting valve. As the lever is dropped below the proper running cut-off, as well as when the starting valve is open, the strain on the high-pressure side of the crosshead is decreased and that on the low-pressure side is increased. For this reason, the lever should be dropped a notch or two early enough to avoid having to go clear into the corner, or opening the starting valve. The starting valve should not be opened until the reverse lever has been gradually notched forwards and is in the last notch, and the locomotive is in danger of being stalled, and it should be closed as soon as the danger of stalling is passed.

**34. Handling a Vauclain.**—In starting a train with a Vauclain compound, first place the reverse lever in the corner notch, then move the cylinder-cock lever to its forward position, to open the cylinder cocks and starting valve, and then open the throttle. As soon as the cylinders are free from water and the train has attained a speed of from 4 to 6 miles per hour, move the cylinder-cock lever to its mid-position, thus closing both the cylinder cocks and the starting valve, and causing the engine to work compound. If the engine is equipped with the other style starting valve, move it to closed position. After closing the starting valve, and as the speed of the train increases, hook up the reverse lever a

notch or two at a time until the proper speed is attained. If the locomotive at any time develops more power than is required with the reverse lever in any notch, hook it up a notch or two more; and if, with the lever in the last notch and the high-pressure cylinder cutting off at about half stroke, it should still develop too much power, partly close the throttle and thus reduce the power developed. If running on a down grade on which it is not necessary to work steam in the cylinders, keep the throttle open just a "crack," so as to allow sufficient steam in the cylinders to assist in lubricating the parts and prevent the formation of a vacuum, which retards the movement of the piston. A sufficient amount of steam for this purpose will just keep the relief valves closed. Should the grade be such as to prohibit this practice, close the throttle and gradually move the reverse lever—a few notches at a time—toward the forward corner, and then move the cylinder-cock lever to its backward position, in which it opens the starting valve only, since this allows air to circulate either way, through the pipe *t*, thus relieving the vacuum formed and making the engine drift more easily.

**35.** A reference to Figs. 13 and 14 will show that, in this position of the starting valve, the pipe *t* connects the two ends of the high-pressure cylinder together; also, since the chamber *i* leads to the back end of the low-pressure cylinder, it will be plain that, with the steam valve *V* (i. e., the piston valve) in the position shown (see also Fig. 10), the front end of the high-pressure cylinder is connected with the back end of the low-pressure cylinder through the valve *V*; while, with the valve *V* in its back position (see also Fig. 11), the back end of the high-pressure cylinder connects with the front end of the low-pressure cylinder through chamber *j*. Thus, it will be seen that, when the engine is drifting with the starting valve open, the air that is compressed on one side of the high-pressure piston is free to flow to the other side of both the high-pressure and the low-pressure pistons, thus preventing, to a considerable extent, the formation of a vacuum there. Also, when the style of cylinder cock indicated is used (with

small check-valve), and the starting valve is in its backward position—so as not to open the cocks—any vacuum in either end of the low-pressure cylinder will cause the check-valve of the cylinder cock on that end to open and admit air, while the pressure in the opposite end of the cylinder, due to compression, will hold the check-valve in the other cylinder cock seated. It is better that the cylinder cocks should not be opened when drifting, as otherwise the air discharging from the low-pressure cylinder will carry oil with it; consequently, the cylinders will be more liable to become dry and cut. The proper position for the reverse lever, when drifting, is as near the corner as practicable.

On an up grade, as soon as the engine shows signs of slowing down, drop the reverse lever a notch or two, and continue to notch forwards as necessary until the lever is in the corner notch; then, should the train continue to slow up so that there is danger of stalling, open the starting valve until the danger is past, whereupon it should be closed. Compound engines of this type require about the same amount of cylinder oil as a simple engine of equal size and power; hence, the lubricator cylinder feeds should be set accordingly. When drifting, the low-pressure requires more oil than the high-pressure cylinder, for which reason some roads connect one feed of the lubricator to the low-pressure cylinder steam port. If no provision is made for lubricating the low-pressure cylinder separately in case of running long distances shut off, oil can be put in at the relief valves. Also, the wear of the crosshead and guides requires close attention to prevent lost motion. On account of the unequal strains that the crosshead is subjected to at all cut-offs, other than the proper running cut-off, the wear on some parts of the crosshead is excessive. The successful operation of this type of compound depends largely on the condition in which the crossheads are maintained. The wearing surfaces of the guides and crosshead are now being made considerably larger than formerly, so that the wear is much reduced.

### BREAKDOWNS

**36. Broken Main Rod.**—In the event of a main rod breaking, place the steam valve on that side in the center of the valve seat, as in Fig. 5—in which position all the ports are covered—and clamp it there, remove the broken rod, and securely clamp the crosshead; then run in with the other side. In engines having the direct valve gear, in which the valve stem is connected to a small crosshead, the valve will be properly placed if this crosshead is blocked, so as to be in the center of the guides.

**37. Broken High-Pressure Piston Rod.**—In the event of a broken high-pressure piston rod, it is possible to proceed without taking down that side of the engine. Take off the front cylinder head—or the pieces, if broken—remove the piston, and then plug the piston-rod hole in the back cylinder head from the inside. Next, replace the front head, if unbroken; or, if broken, clamp a heavy board over the end of the cylinder so as to make a joint as nearly steam-tight as possible; the engine is then ready. The steam will be distributed to this cylinder as though the piston were in place; but, instead of doing work there, it will pass directly through the steam valve to the low-pressure cylinder, the same as the exhaust steam would. Of course, only three cylinders will be available for work, but the locomotive can be handled the same as before the accident occurred.

**38. Broken Low-Pressure Piston Rod.**—In case this piston rod breaks, take off the front cylinder head, remove the piston, and plug the piston-rod hole in the back cylinder head from the inside, as in the case of the high-pressure cylinder. Replace the cylinder head, and proceed with the run, using three cylinders. In this case, also, the locomotive can be run either simple or compound. If the front head is also broken, you can proceed without it, after removing the piston, the exhaust steam from the high-pressure cylinder being allowed to exhaust through the opening thus made. If the escaping steam obstructs the view so that it is

dangerous to run with it thus escaping, try to board up the end of the cylinder, or, failing in that, take down that side of the engine and proceed by using the other side. If the cylinder head only is broken, proceed as above, only do not remove the piston.

**39. Broken Valve Stem.**—In the event of a broken valve stem, clamp the valve in the center of its seat so as to cover all the ports, then take down the main rod, securely clamp the crosshead, and run in with the other side.

**40. Other Breakdowns.**—Broken packing rings, in either the steam valve or cylinder piston, are very difficult to detect, and generally can only be noticed in their effect on the engine; that is, when the rings are faulty, the engine steams poorly and will not make time on the road. The low-pressure piston packing rings require renewal more frequently than those of the high-pressure piston. Sometimes the cylinder-cock shaft *T*, Fig. 12, becomes strained, so that, when the cylinder-cock lever is moved, it will open the starting valve on one side of the engine, but will not open the one on the other side. This causes the exhaust to sound alternately light and heavy, and the trouble is very apt to be attributed to the valve gear; hence, before altering the valve gear, examine the starting valves, to see whether they open and close simultaneously, and examine, also, the steam valve and low-pressure piston for broken rings.

**41. Blows.**—In this type of compound, it is of great importance to be able to accurately locate blows without having to make an actual examination of all the parts through which the blow is liable to occur. This is especially true in the low-wheel type of locomotive, where the steam chest is located low down and inside the frames; for in this arrangement it is necessary, in many cases, to drop the engine truck in order to get the valve out for examination.

The engineer is first warned of a blow by noticing a peculiarity of the exhaust. When there is a leaky valve or a leaky piston packing, the sound of the exhaust differs somewhat from that produced when there is a derangement in the valve

gear, so that by noting the position of the crankpin as the exhaust occurs and listening to the sound of the exhaust as the engine is run slowly along, the source of the blow can usually be determined. Care must be taken, however, not to mistake two heavy exhausts from one side for two light exhausts from the other side, or vice versa. Some defects will cause the exhausts from one side to sound heavier, while other defects will cause them to sound lighter than they should, so that to properly locate the defect it is necessary to distinguish the sound of the normal exhaust.

If the exhausts occur at irregular intervals and one exhaust is heavier and one lighter than the other two, the trouble will be found somewhere in the valve motion, and its location and remedy will be the same as in a simple engine. If the exhausts are at regular intervals, but of varying volume, the trouble will be found in the piston or valve packing, or in the starting valve or its connections. When running slowly, watch the right side, and if it is found that every time the engine passes the quarters a heavier exhaust occurs than when it passes the centers, either there is a leak of live steam into the low-pressure cylinder on the left side, thus accounting for the heavy exhaust from that side, or there is a leak past the low-pressure piston on the right side, which allows some of the steam to escape before the exhaust takes place, thus reducing the volume of sound when the exhaust does occur.

Two heavy exhausts on a side will usually be traced to broken high-pressure packing rings, although it may be caused by a leak past the valve, a loose bushing, leaky starting valve, or any other defect that will permit leakage of high-pressure steam into the low-pressure cylinder.

Two light exhausts are due to an escape of steam from the low-pressure cylinder and are due usually to broken piston rings, or broken valve rings.

In some cases, the irregularity may be caused by the connections to the starting valve being out of order. When the cylinder cocks and starting valve are operated by one lever, the starting valve is under the cylinder, and the rods and

lever connections are sometimes bent by striking obstructions along the road; this alters their length so that, with the lever in the cab in its proper position, the altered length of the connections will throw the starting valve out of its proper position. If the connections for one side are so bent that the starting valve is opened when the cylinder-cock lever is in compound position (position *1*, Fig. 12), it will allow live steam to go to the low-pressure cylinder on that side, and a heavy exhaust will occur from that side. If by placing the cylinder-cock lever in live-steam position (position *3*, Fig. 12) the exhausts are made equal, the trouble will probably be found in the connections.

**42.** If the starting valve is all right, but it is thought that the engine is not doing its work as well as usual, look for the trouble on the side from which the light exhaust is coming, which, in this case, is the right side. To determine this, place the engine on the quarter on the right side with the reverse lever in the corner and the starting valve in position *3*, Fig. 12 (live-steam position); block the drivers or set the brakes, open the throttle, and then open the cylinder cock, or remove the indicator plug from the end of the low-pressure cylinder opposite that containing steam. If steam escapes, it indicates that the low-pressure cylinder packing is leaking on that side. This test is practically the same as the test for a cylinder packing blow in a simple engine.

The trouble might be in the valve rings *5* and *6* or *7* and *8*, Fig. 15 (*b*), though not likely. This can be proved by bringing the reverse lever to the center notch, when, if the rings *5* and *6* or *7* and *8* are leaking, steam will continue to blow out of the cylinder cock until all the steam trapped in the inner cavity of the valve escapes. If but one pair of rings is leaking, the exhaust will indicate this by giving three normal exhausts and one light one.

If the trouble is not found on the right side, the heavy exhaust is the abnormal one, and the trouble should be looked for on the left side. Place that side of the engine on the quarter, with the starting valve in closed or compound position,

place the reverse lever in the corner, and open the throttle. An indication of pressures in the ends of the high-pressure cylinder can be had by slacking off on the union nuts at each end of the live steam pipe *t*, Fig. 12. If steam blows from each, it indicates that either the valve or the high-pressure piston packing is blowing. If, on bringing the reverse lever to the center notch, the blow ceases, the trouble will be found in the high-pressure piston packing; but if the blow continues, it will be the valve packing, though the piston packing may be blowing also. To determine if it is the piston packing, the valve packing must be made tight; if the engine still blows, the piston packing is leaking. If the blow is past either pair of valve rings *1* and *2* or *3* and *4*, a heavy exhaust will be had from each end of the cylinder, as steam leaking into either end of the inner cavity of the valve will find its way into whatever port the other end of the cavity may be in connection with. When indicator plugs are placed in the cylinders, they may be removed to determine whether leakage occurs in the test. Most engines that have the starting valve independent of the cylinder cocks have cylinder cocks leading from the high-pressure cylinders, and these, when opened, will be the most convenient indication of the pressure in the opposite ends of the high-pressure cylinder. Sometimes the steam-chest bushing does not make a tight fit with the walls of the chest and allows steam to leak from one part to another, giving a blow that can only be located after all other possible places for a blow have been examined. By tapping with a hammer on the inside of the bushing, the defective joint can sometimes be determined by the difference in sound.

**43.** Small pieces of broken packing rings find their way into the cylinder cocks and get under the valves and hold them open, thus giving a sure indication on which side to look for the trouble. The large size cylinder cocks used in this type of engine make it imperative that when one is broken off, as is frequently the case, the opening be plugged securely, as the steam blowing out naturally affects the

power of the locomotive, and will cover the working parts with dirt and gravel. To plug these holes securely, place the engine on the center, so that the following head will be over the opening; then make a wooden plug of a proper fit, split it on the small end and insert a wedge in the split, and then drive the plug in securely. It is a good plan to make a small groove in the side of the plug to allow the accumulation of water in the cylinder to drip out.

# CROSS-COMPOUND LOCOMOTIVES

## PRINCIPAL TYPES

### BALDWIN TWO-CYLINDER COMPOUND

#### DESCRIPTION

1. **General Arrangement.**—The general arrangement of the high- and low-pressure cylinders and of the intercepting valve of the Baldwin two-cylinder compound locomotive is shown in Fig. 1. In this type of compound, the high-pressure and low-pressure cylinders are arranged similar to the cylinders of a simple engine, and the distribution of steam to the cylinders is effected by means of slide valves operating in the steam chests *S*, *S*. There is but one steam pipe *D* in the smokebox, and that connects with the steamway in the cylinder saddle that leads to the steam chest of the high-pressure cylinder *A*. The end *Y* of the receiver connects with a special passage in the saddle that leads to the intercepting valve *C*, while the other end *Z* of the receiver connects with the steam passage that leads to the steam chest of the low-pressure cylinder *B*. The exhaust pipe *P* connects with the regular exhaust passage leading to the low-pressure cylinder, and also, through a special passage, with the intercepting valve, which is situated in the same half saddle as the high-pressure cylinder; hence, by the action of the intercepting valve, as will be explained, the exhaust steam from the high-pressure cylinder may be made to go either through the receiver *YZ* and the cylinder *B* and its exhaust passage to

the exhaust pipe *P*—as when the engine is working compound—or direct through the special passage to the exhaust pipe and the atmosphere without entering the receiver, as when working simple. Also, there is a special passage that connects with the steamway to the high-pressure cylinder and leads through the reducing valve *K* to the steam chest

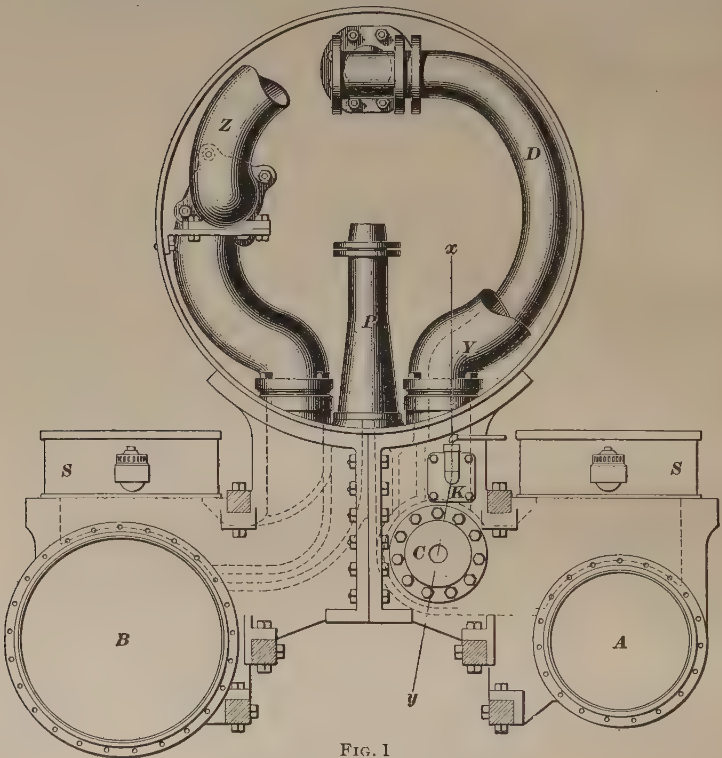



Fig. 1

of the low-pressure cylinder; it is through this passage that live steam is admitted to the low-pressure cylinder while the engine is being worked simple.

**2. Intercepting Valve.**—If the cylinder saddle, Fig. 1, were cut through on the line *x y*, and the high-pressure cylinder part removed, the left-hand part would present a sectional view of the intercepting and reducing valves similar to

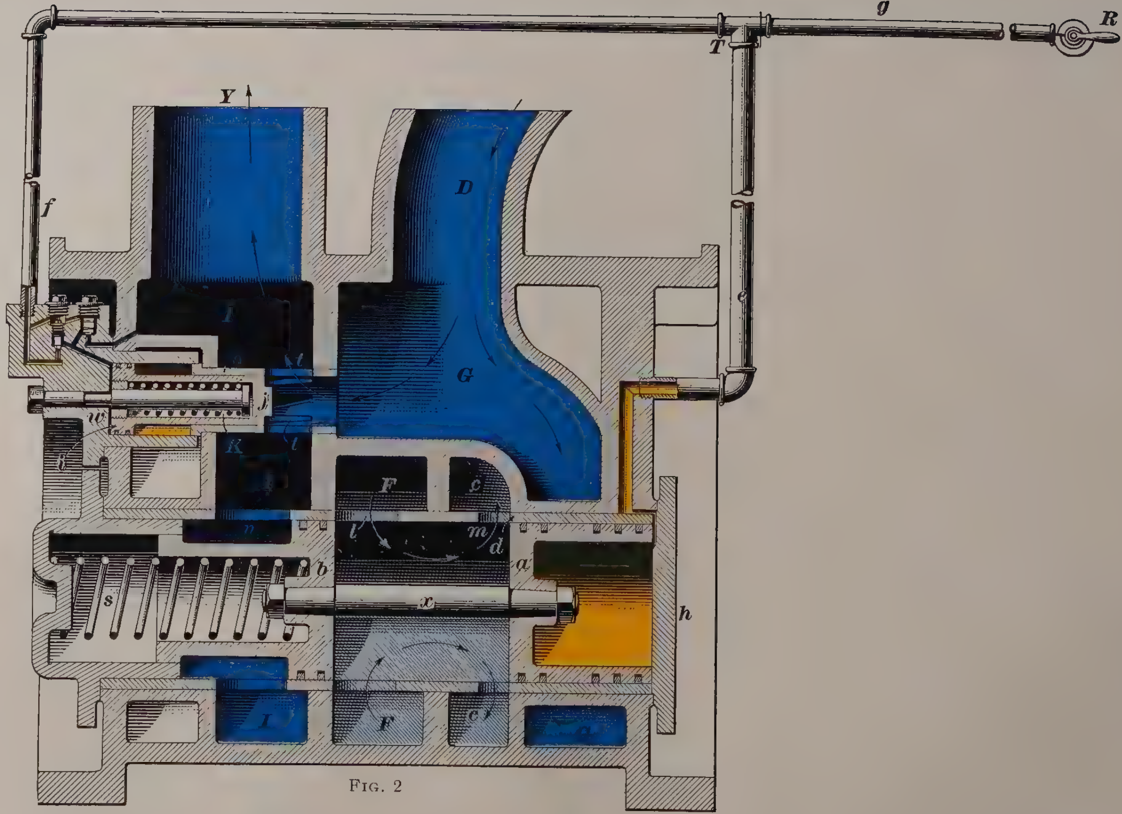


Fig. 2

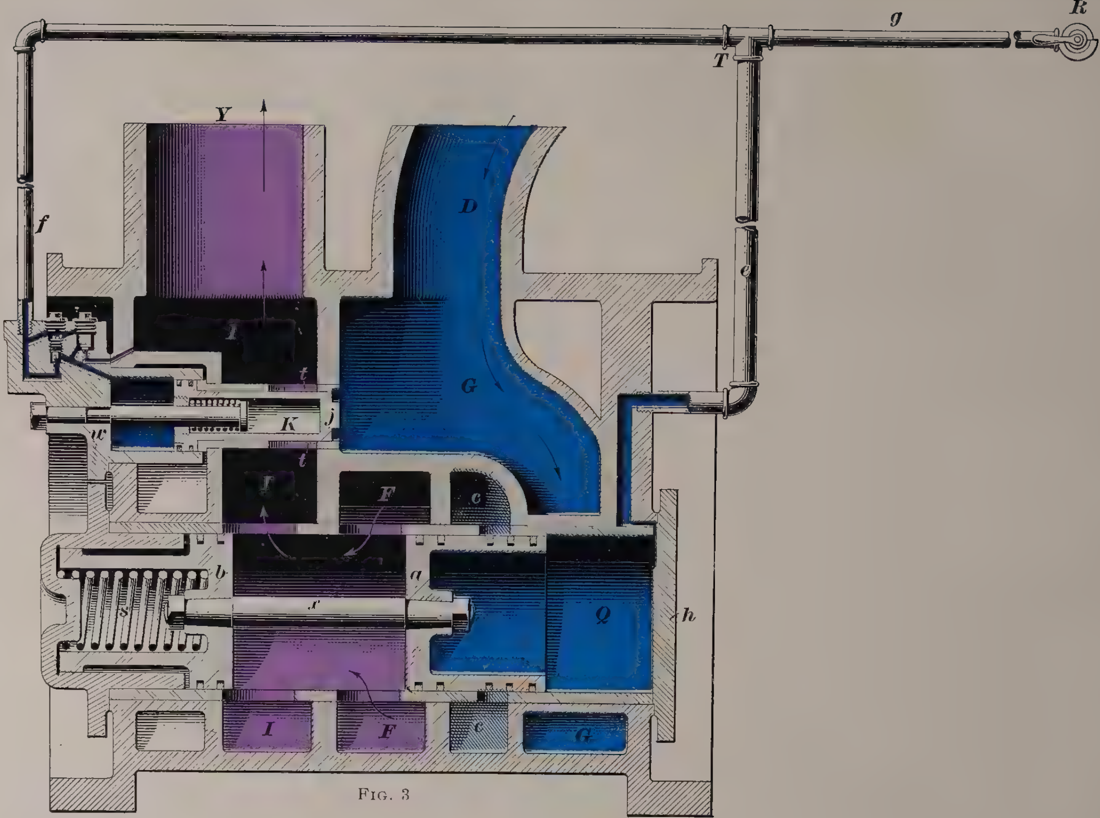



FIG. 3

that shown in Figs. 2 and 3, depending on whether the intercepting and reducing valves were in simple or in compound position.

The intercepting valve consists of two pistons *a*, *b* connected together by means of the rod *x*, which also holds the pistons a definite distance apart. The valve is made to work steam-tight within the bushing *d* by means of packing rings, as shown. The bushing is provided with three ports *l*, *m*, *n* that connect with the chambers *F*, *c*, and *I*, respectively. Chamber *F* connects with the exhaust steamway of the high-pressure cylinder, chamber *c* connects with the special passage that leads direct to the exhaust pipe, while chamber *I* connects with the end *Y* of the receiver. When the engine is working simple, the spring *s* holds the intercepting valve in its extreme backward position against the head *h*, Fig. 2, in which position the cavity between the pistons *a* and *b* connects chambers *F* and *c*, and the piston *b* cuts off port *n*, thus closing communication between the chambers *c* and *F* and chamber *I*. When working compound, the valve is held in its extreme forward position, as shown in Fig. 3, in which position the cavity in the valve connects the chambers *F* and *I*, and the piston *a* closes port *m*, Fig. 2, leading to chamber *c*. The valve is moved forwards (to compound position) by admitting steam pressure to the chamber *Q* between the piston *a* and the head *h*; it is moved backwards (to simple position) by removing this pressure and allowing the spring *s* to force back the piston.

The duty of the intercepting valve, it will be observed, is simply to divert the exhaust steam of the high-pressure cylinder as it issues from chamber *F*, either directly to the exhaust pipe through chamber *c*, as when working simple, Fig. 2, or through chamber *I* into the receiver and thence to the low-pressure cylinder, as when working compound, Fig. 3. Live steam from the steam pipe *D* enters the steamway *G* and flows around the intercepting valve to the high-pressure steam chest; the intercepting valve, however, does not affect the live steam, its duty being entirely with the exhaust steam of the high-pressure cylinder.

**3. Reducing Valve.**—When the engine is working compound, live steam enters and is expanded in the high-pressure cylinder *A*, and, after expansion, is exhausted into the receiver *Y Z*, from whence it passes to the low-pressure cylinder *B*. In the compound position, therefore, the steam supply for the low-pressure cylinder comes from the high-pressure exhaust steam; but, in the simple position, this exhaust steam discharges directly into the atmosphere, and it then becomes necessary to supply the low-pressure cylinder with steam at a reduced pressure from the boiler. Also, since the area of the low-pressure piston is about two and one-half times the area of the high-pressure piston, the pressure of the steam admitted into the low-pressure cylinder must be regulated so that the total force exerted on the two pistons will be equal. It is the duty of the **reducing valve** *K* to perform both these functions. In other words, one duty of the reducing valve is to admit live steam at a reduced pressure into the receiver when the engine is working simple, and to exclude live steam from the receiver when the engine is working compound, since it is not then required; the other duty is to so regulate the pressure in the receiver, when live steam is being admitted, that the total force exerted on the pistons in the two cylinders will always be equal, regardless of the pressure of the steam in the steam pipe. The reducing valve remains inoperative during the time the engine is working compound.

**4.** The reducing valve *K*, Fig. 2, consists of two pistons *i*, *j* connected together by means of a sleeve. A spring is so arranged within the sleeve that it tends to hold the valve open—that is, in its forward position—as shown in Fig. 2. The valve works steam-tight within a bushing *o*, the back end of which is furnished with the ports *t*, so that, when the valve is in the position shown in Fig. 2 (position for working simple), live steam can pass from the chamber *G* through the ports *t* and into chamber *I*, and thence to the receiver. When the valve is moved to the position shown in Fig. 3 (compound position), no steam can pass between the

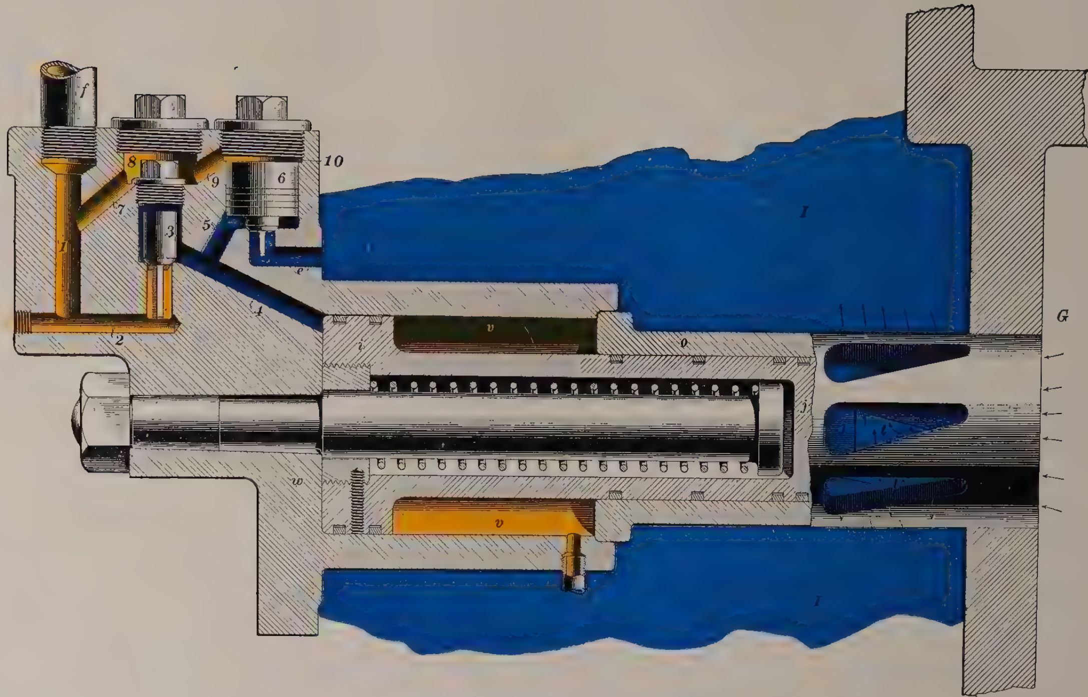



FIG. 4

chambers *G* and *I*, because the ports *t* are covered by the valve *K*. This valve can be moved, at will, backwards to its compound position by introducing steam pressure into the space *v* between the piston *i* of the valve and the end *w* of chamber, while it is forced forwards to simple position by the action of the spring as soon as the pressure in chamber *v* is removed. How the valve performs its functions can best be explained in connection with Fig. 4, which is a sectional view of the valve in simple position. In this position, live steam flows from chamber *G* through the ports *t* into chamber *I*, and thence to the receiver, as indicated by the arrows. While the reducing valve must be made to perform one of its duties, it is perfectly automatic in the performance of its other duty, namely, the work of regulating the pressure in the receiver when the engine is working simple. The reducing valve is then operated automatically by the pressure in the receiver, and it will close the ports *t* as soon as the pressure in the receiver is great enough to equalize the force exerted on the two pistons *j*, *i*, or it will open the ports should the pressure fall below that amount. Its operation as a pressure regulator is as follows: Live-steam pressure in chamber *G* is exerted on the face of the piston *j*, and tends to hold the valve open; the steam pressure in the receiver, on the other hand, passes through port *e*, raises valve *6*, and then flows through the passages *5* and *4* into chamber *v* (see Fig. 4), and thus acts against the face of the piston *i*, with a tendency to close the valve. Now, the piston *i* has about two and one-quarter times* the area exposed to the receiver steam that piston *j* has exposed to the live steam; hence, when the pressure in the receiver is a little less than half that of the live steam, the valve will be moved backwards and the ports *t* closed. When the pressure in the receiver is reduced so that the force exerted by the steam on *j* is sufficiently greater than that exerted on *i* to compress the spring, the valve will open; and so the action of the valve is carried on.

*The two pistons *j*, *i* are so proportioned that equal cylinder power will be given to both sides of the engine, regardless of the amount of pressure carried in the boiler.

**5.** When the engineer wishes to work the engine compound, he admits steam (through the pipe *f*) to chamber *v* back of the piston *i* of the reducing valve; steam flowing from *f* passes through the passages *1* and *2*, raises valve *3*, and passes on through *4* to chamber *v*, and forces the reducing valve backwards, closing the ports *t*. Live steam cannot then enter the receiver, which is being supplied with steam by the high-pressure cylinder exhaust. It will be observed that pressure can pass to chamber *10* above valve *6* through the passage *7*, chamber *8*, and passage *9*; hence, valve *6* is held firmly on its seat during the time that the pipe *f* is charged with pressure.

**6. Operating Valve.**—Referring to Figs. 2 and 3, it will be seen that the pipes *e* and *f* are joined together at *T*, and are connected, by means of pipe *g*, to the operating valve *R* that is situated in the cab. It is by means of this valve that the engineer is enabled to change, at will, the intercepting and reducing valves from the simple to the compound position, or from the compound to the simple. It will be noted that with this type of compound the intercepting and reducing valves are held in compound position by steam from the cab, whereas all other types, except the Pittsburg, are held in simple position by steam or air from the cab.

A cross-sectional view of the operating valve is shown in Fig. 5 (*a*), and a plan of it in (*b*). As will be seen, the valve has three pipe connections *X*, *Y*, and *Z*; the connection with pipe *g*, Fig. 2, is made at *X*, Fig. 5, the connection to the boiler at *Y*, while a pipe that opens to the atmosphere is connected to *Z*. Part of the valve stem is broken away, view (*a*), in order to show the steam connection *Y*. The valve *V* has two seats, one at *a*, on which it is shown seated, and the other at *b*. A handle *N* is connected with the valve spindle *S*, and the spindle is provided with screw threads *c* so constructed that half a turn of the handle will move the valve *V* from one of its seats to the other, depending on the direction in which the handle is turned. There are two positions in which the handle *N* is carried; these positions, one

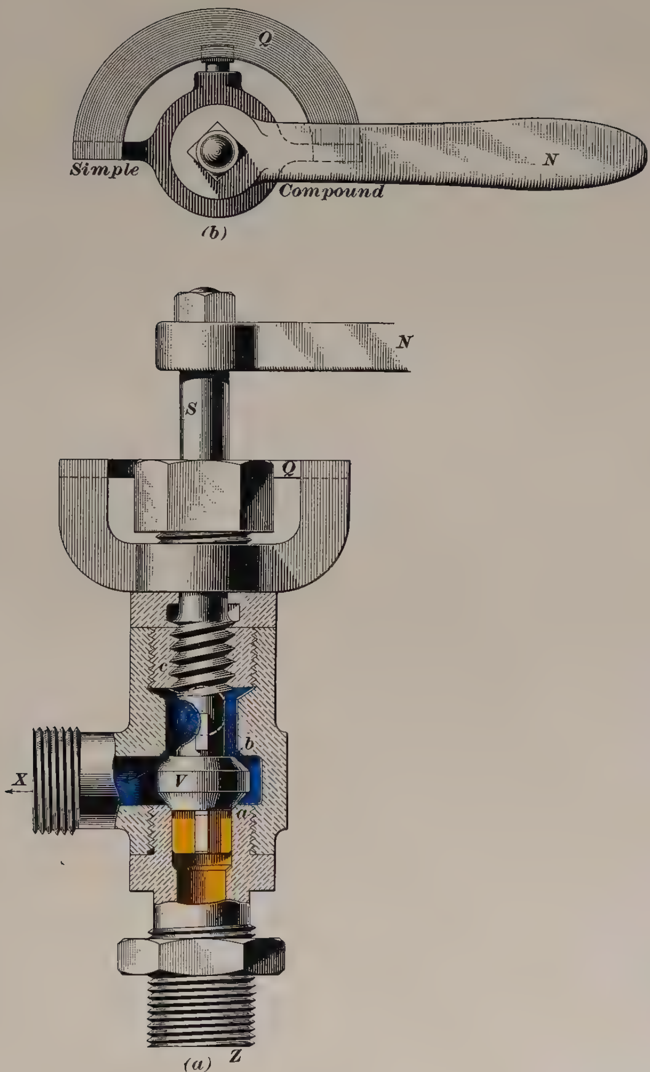



FIG. 5

simple and the other compound, are marked on the quadrant *Q*. When the handle is in the position marked compound, the valve *V* is on its lower seat *a*, as shown in the figure, and steam can then flow from the boiler through the connection *Y*, past the valve, and out through *X* and pipes *g*, *e*, and *f*, Fig. 3, to the chambers *Q* and *v*, forcing the intercepting and reducing valves to their compound positions. The engine is then working compound. By turning the handle to the position marked simple the valve *V* is raised to its upper seat *b*, thus cutting off the supply of steam from the boiler through *Y*; also, by raising the valve, the opening into the drip pipe *Z* is uncovered, and the steam pressure caught in the pipes *g*, *f*, and *e* discharges instantly to the atmosphere. This removes all pressure from the chambers *Q* and *v*; and, consequently, the intercepting and reducing valves assume their simple positions, Fig. 2, and the engine works simple.

---

## OPERATION

**7.** The Baldwin two-cylinder compound can be worked either as a simple or as a compound engine, at the will of the engineer, and the change can be made simply by moving the handle of the operating valve so as to shift the intercepting valve to the proper position. When the engine is at rest, the handle of the operating valve is in the position marked *simple*, and the engine is then in condition to work as a simple, or single-expansion, engine, since both the intercepting and reducing valves are in the simple position. The intercepting valve diverts the exhaust steam from the high-pressure cylinder into the special exhaust passage *c*, and thence to the exhaust pipe, while, at the same time, the reducing valve is wide open, allowing live steam to flow from chamber *G* into the receiver, from which the low-pressure cylinder draws its supply.

The locomotive can be used as a simple engine in making up trains and in starting trains; but, when the train is once fairly started, the engine should be worked compound, which is accomplished by moving the handle of the operating valve

to *compound* position. This, as has been explained, admits steam from the boiler into the pipes *e* and *f*, which instantly moves both the intercepting and the reducing valves to the compound position. The exhaust steam from the high-pressure cylinder then passes into the receiver, instead of passing directly to the atmosphere, and forms the supply for the low-pressure cylinder, the reducing valve being held closed by the steam pressure in chamber *v*. Should there be danger of stalling at any time, the locomotive should be changed to work simple until the danger of stalling is past, since more power is developed when working simple than when working compound. The reason that a cross-compound has more power when working simple than when working compound, is that at such times the high-pressure piston is relieved of the back pressure from the low-pressure cylinder; in this case the high-pressure cylinder exhausts directly to the atmosphere. In addition to this, live steam at about half the boiler pressure is used in the low-pressure cylinder.

---

## BREAKDOWNS

**8. Broken Main Rod on the High-Pressure Side.** In the event of a main rod on the high-pressure side breaking, take it down, block the crosshead securely at the back end of the guides, disconnect the valve rod of the high-pressure valve, and place the valve in the center of its seat, so that it will block the ports, and clamp it there; place the handle of the operating valve in simple position, and proceed, using the low-pressure side only. With the operating valve in simple position, as recommended above, the intercepting and reducing valves will be moved to simple position by their springs, and the low-pressure side will be supplied, through the reducing valve, with live steam.

**9. Broken Main Rod on the Low-Pressure Side.** In case the main rod on the low-pressure side breaks, take it down and block the crosshead at the back end of the guides; disconnect the low-pressure valve stem, and clamp the valve in such a position that it will cover both ports; move the

handle of the operating valve to simple position, and proceed, using only the high-pressure cylinder of the engine. Referring to Fig. 2, it will be seen that live steam will pass from chamber *G* to the high-pressure cylinder, and will exhaust through the emergency exhaust passage *c* directly to the atmosphere, without entering the receiver.

**10. Broken Valve Stem.**—In the event of either valve stem breaking, take down the main rod on that side, block the crosshead at the back end of the guides, clamp the valve in the center of its seat, and proceed, carrying the handle of the operating valve in simple position.

**11. Failure of Intercepting or Reducing Valves.** If either of these valves fails to operate properly, so that it is necessary to locate and remedy the trouble, take the head off the bushing of the valve causing the trouble, remove the valve, and ascertain and remedy, if possible, the cause of the improper operation of the valve.

**12. Blows.**—Blows that occur in the slide valves and piston packing of a Baldwin two-cylinder compound engine are located as in a simple engine by working the compound engine in simple position. Steam is required in chambers *v* and *Q* to hold the reducing valve closed and the intercepting valve in compound position, as shown in Fig. 3. Any mishap that cuts off this steam supply will require the engine to be worked simple until repairs can be made.

Should the reducing valve *K* not make a tight joint in its bushing, it will allow live steam to flow into the receiver, thus increasing the pressure in the low-pressure cylinder, and an unequal amount of work will be done in the two cylinders.

## RICHMOND COMPOUND

### DESCRIPTION

**13. General Arrangement.**—Fig. 6 is a front view of the latest type of Richmond compound engine, showing the relative positions of the high-pressure cylinder *A*, low-pressure cylinder *B*, and intercepting-valve chamber *C*, together with the arrangement of the steam pipes *D*, *E* and the

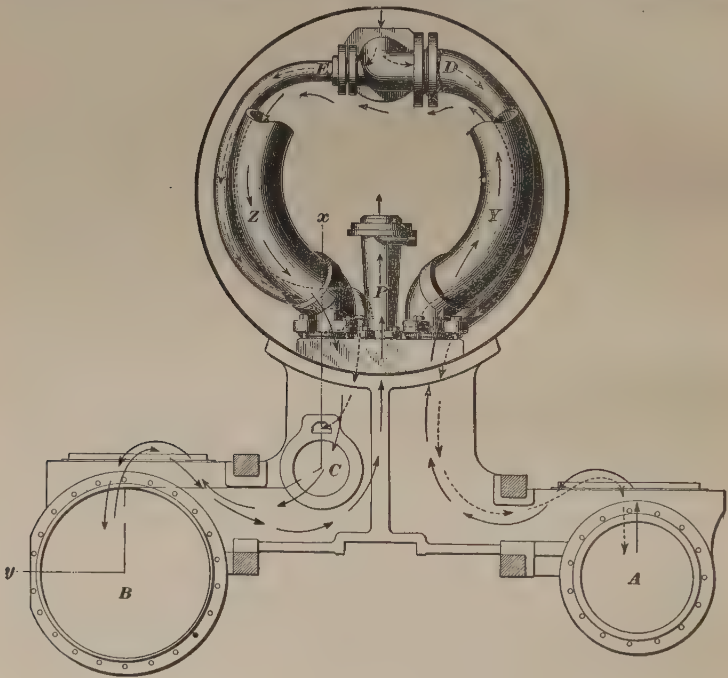



FIG. 6

receiver *YZ*. The upper part of the receiver is broken away, in order that the steam pipes may be seen; it will be observed that the steam pipes are of unequal diameter. The one marked *D* is of the usual size, and connects directly with the steamway in the cylinder saddle that leads to the high-pressure steam chest to which it supplies steam. The pipe *E*

is much smaller, being only 3 inches in diameter, and connects with a special steamway that leads to a chamber surrounding the reducing valve. The exhaust passage from the high-pressure cylinder connects with the end *Y* of the receiver, the other end *Z* of which connects with a special passage that leads to the intercepting-valve chamber *C*. Also, a passage (the steamway to the low-pressure cylinder) leads from the intercepting valve to the steam chest of the low-pressure cylinder, while the exhaust passage from this cylinder leads directly to the exhaust pipe *P*.

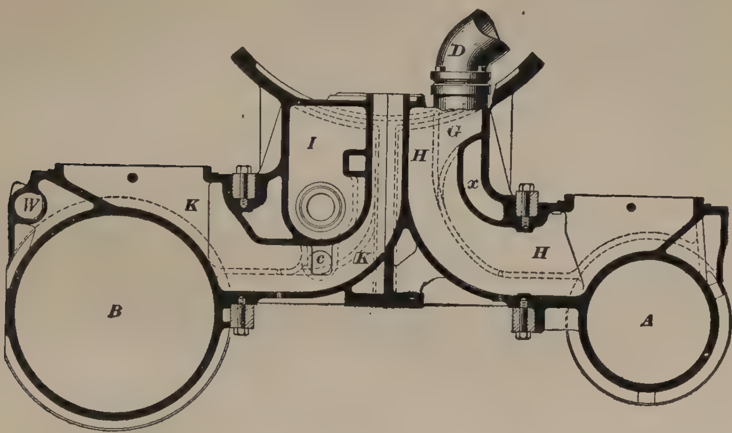


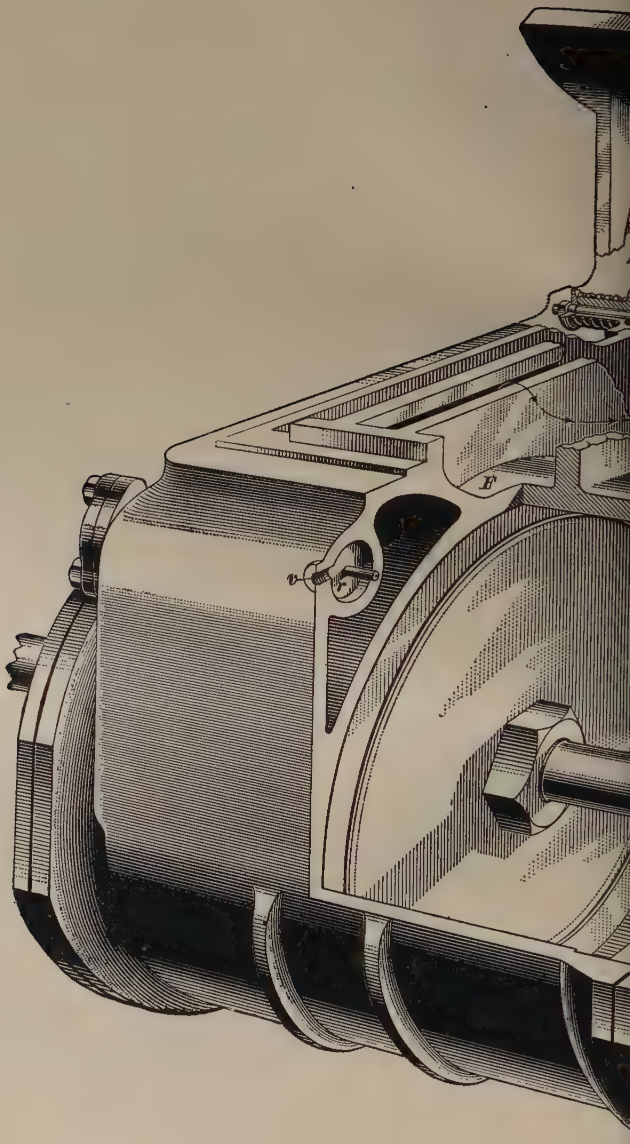

FIG. 7

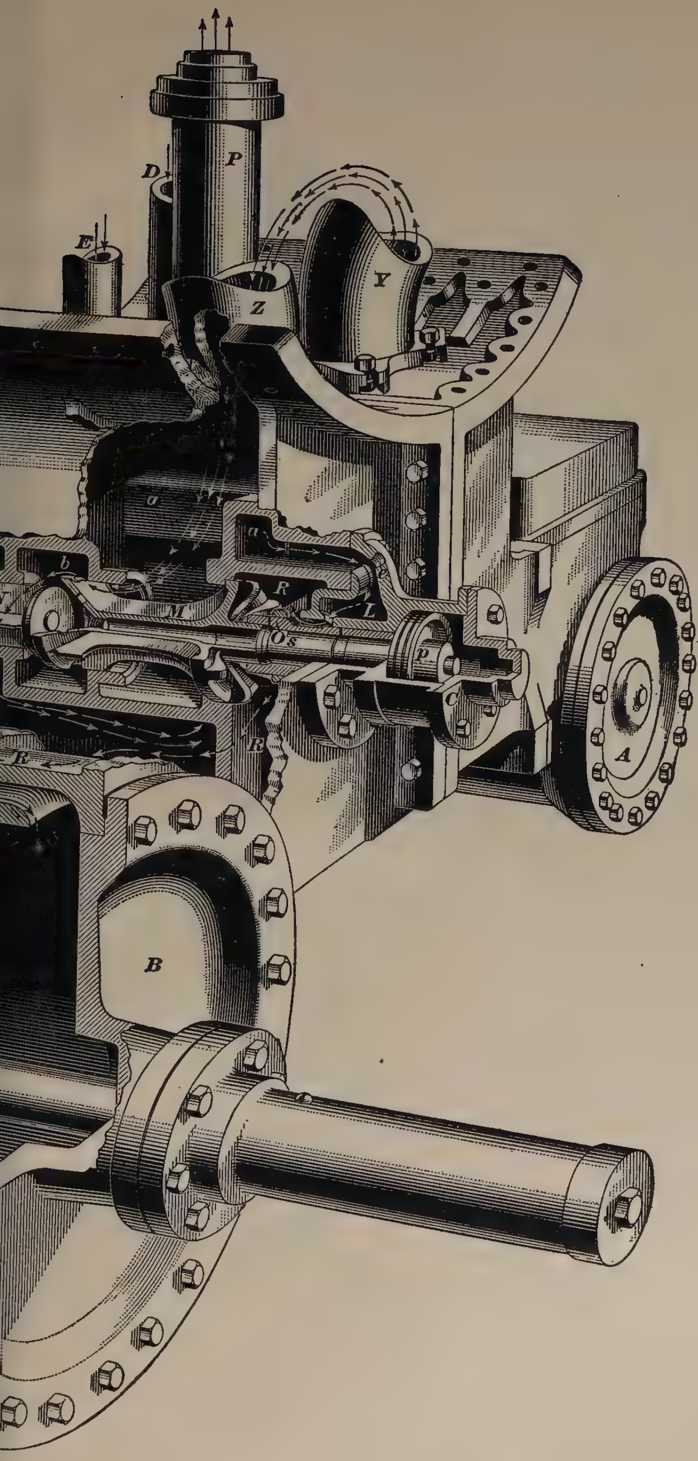
This will be seen more clearly by referring to Fig. 7, which is a sectional view taken through the exhaust passages. The steam pipe *D* connects with the steamway *G*; this steamway divides into two branches, one of which connects with the back end, and the other (marked *x*) with the front end of the steam chest. The exhaust passage *H* leads to the receiver. On the low-pressure side, *I* is the chamber with which the end *Z* of the receiver connects, while *K* is the exhaust passage that leads to the exhaust pipe. The distribution of steam to the steam cylinders is effected by means of slide valves operating in the steam chests. *W* is the chamber in which the overpass valves work.

**14. Arrangement of Intercepting Valve, Etc.**—A perspective view of the Richmond compound engine is given in Fig. 8, in which a part of the low-pressure cylinder and the left half of the saddle have been broken away (on the line $xy$, Fig. 6), in order to show the relative positions of the different valves and passages; also, the low-pressure steam chest has been removed. In the figure, $M$ is the intercepting valve, by means of which the exhaust steam from the high-pressure cylinder is discharged either into the low-pressure cylinder when the engine is working compound, or directly to the exhaust pipe when it is working simple. The valve $N$ is called the *emergency valve*, since, by its use, the engineer can change the engine from compound to simple at will. This is accomplished, as will be explained further on, by causing the valve to open a special passageway $c$ between chamber $I$ and the regular exhaust passage $F$.

The reducing valve $O$ is merely a cylindrical sleeve capable of sliding back and forth a distance of 1 inch on the stem $s$ of the intercepting valve; its duty is to admit live steam at a reduced pressure into the low-pressure steam chest during the time the engine is working simple, and to regulate the pressure there to a certain percentage of that of the steam used in the high-pressure cylinder. The piston $p$ on the valve stem $s$ acts as an air dashpot for the intercepting valve, to prevent the valve slamming on its seat.

**15.** The chamber $I$ connects directly with the end $Z$ of the receiver. The 3-inch steam pipe $E$ connects with the passage $a$ that ends in the chamber $L$ surrounding the reducing valve. The passage $R$ is the steamway that leads directly to the low-pressure steam chest; it is connected with chamber $L$ through the reducing valve $O$, and with the chamber $I$ through the intercepting valve $M$. A chamber $b$ separates chamber $I$ from the emergency exhaust passage $c$, and the exhaust passage leads directly to the regular exhaust passage $F$. The overpass valves $r$ are shown also, while an air-discharge valve is connected with the opening that is directly below the exhaust valve $N$. The different valves are


F
v
r




G. 8

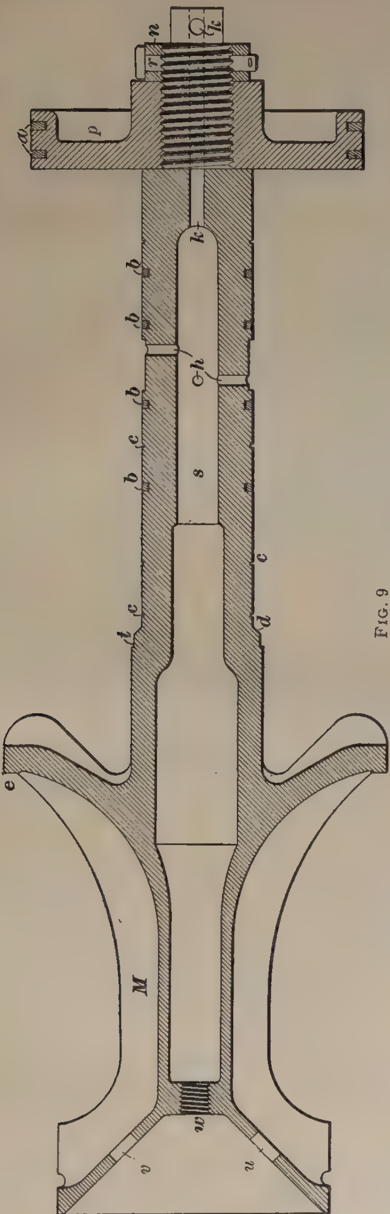


FIG. 9

shown in their simple positions—that is, in the positions they assume during the time that the locomotive is being worked as a simple engine. As will be seen by the arrows, the exhaust steam from the high-pressure cylinder passes from the end *Y* to the end *Z* of the receiver, and thence, through chambers *I* and *b*, exhaust valve *N*, and emergency exhaust passage *c*, to the main exhaust passage *F* and the atmosphere. At the same time, steam passes from the small steam pipe *E* through the passage *a* to chamber *L*, thence through the reducing valve *O* and passage *R* to the low-pressure steam chest, as indicated by the arrows. The exhaust steam from the low-pressure cylinder passes directly to the main exhaust passage *F*, as indicated.

**16. Details of Intercepting Valve.**—This valve, sometimes called the *automatic starting valve*, is shown in section in Fig. 9. The piston *p* screws on to the valve stem *s*, and is held in position by the

nut *n* and cotter pin *r*; also, the piston is fitted with two packing rings *a*. The valve stem *s* is fitted with four packing rings *b* and four water-packing grooves *c*. A shoulder *d* is beveled at an angle of 45°, and forms a steam-tight joint on the seat *c* on the inside of the valve *O*, Fig. 10. A groove *t*, Fig. 9, is cut in the shoulder *d*. The end *e* of the valve *M* is finished so as to make a steam-tight joint with its seat.

Two $\frac{3}{4}$-inch holes *u*, *v* are drilled through the small end of the valve, and a steel plug is screwed into the end at *w*. The holes *u*, *v* insure receiver pressure in chamber *b*, and thus assist in balancing the valve *M* during the time that it is in

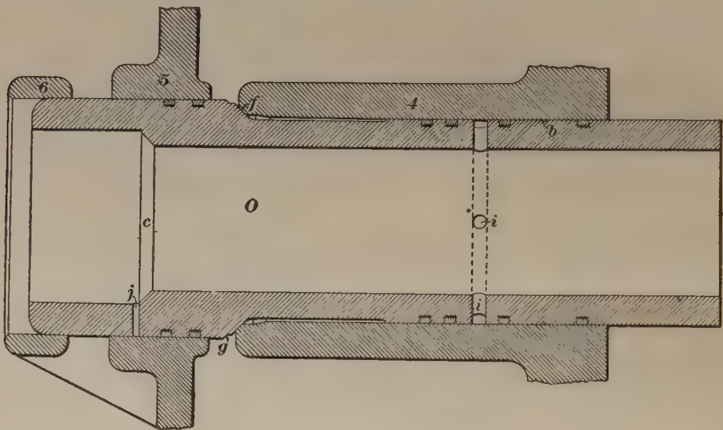



FIG. 10

compound position. The plug *w* is intended merely to plug up the core hole to the inside of the casting. The leakage holes *h* are intended to prevent any steam pressure accumulating under the sleeve, where it would interfere with the proper operation of the valve. The steam leaks through the holes to the bottom of the stem *s*, and thence through the passage *k* in the stem to the outer end of the dashpot, whence it escapes to the atmosphere through the hole *l* in the dashpot head. (See Fig. 11.)

**17. Details of Reducing Valve.**—The reducing valve *O* is shown in section in Fig. 10, in which the parts marked

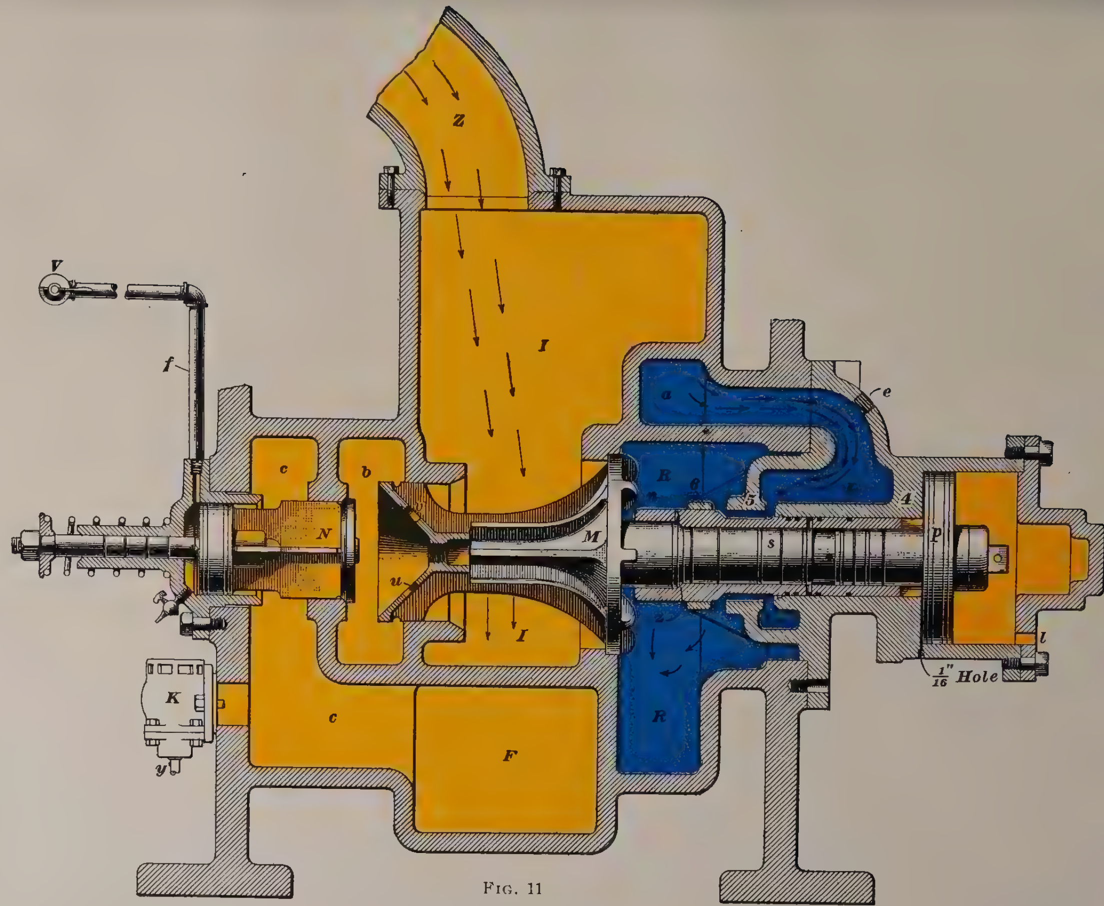



Fig. 11

*4*, *5*, and *6* correspond to the parts similarly marked in Fig. 11. This valve is in the form of a cylindrical sleeve, the inside diameter of which is just large enough to allow the sleeve to slip freely over the valve stem. The sleeve is fitted with six packing rings and a water-packing groove *b*. The shoulder *c* is beveled at a 45° angle, and fits on and makes a steam-tight joint with the shoulder *d* of the valve stem *s*, Fig. 9. A hole *j*, Fig. 10, $\frac{1}{8}$ inch in diameter, is drilled through the sleeve in such a position that when the intercepting valve is closed and the reducing valve open, the hole is directly above the groove *t* in the valve stem, Fig. 9, and steam from chamber *L*, Fig. 11, can then pass through *j* into groove *t*. A 45° beveled joint is also made at *f*, Fig. 10, with the piece *4*, and the shoulder *g* is notched out as shown. The sleeve is about 1 inch shorter than the valve stem *s*, so that it can be moved back and forth on the stem that distance. The holes *i* are leakage holes, and serve the same purpose as the holes *h* of the stem.

**18. Operation of Reducing Valve.**—It will be remembered that the exhaust steam from the high-pressure cylinder discharges directly into the receiver; hence, when the intercepting valve *M* is closed, two or three exhausts will fill the receiver and chamber *I* with steam at the regular receiver pressure. It will readily be seen, also, that, after the throttle is closed, the low-pressure cylinder will quickly relieve the receiver and chamber *I* of all pressure by withdrawing the steam from them; hence, there will be no pressure in the receiver by the time the engine is to be started.

When the throttle is opened in starting the locomotive, steam flows from the boiler into the high-pressure steam chest through the steam pipe *D*, Fig. 8, and also into chamber *L* surrounding the reducing valve through the 3-inch pipe *E* and passage *a*. The steam in chamber *L* exerts a pressure on the shoulder *g* of the sleeve, tending to move the sleeve and intercepting valve into the simple position, as shown in Fig. 11; and, since there is no pressure in chamber *I* (the engine not having exhausted yet), the valves are forced

into that position, thus closing the valve *M* and allowing live steam at a reduced pressure to flow into the passage *R* and the low-pressure steam chest, as indicated by the arrows. This live steam raises the pressure in chamber *R* until it is a little less than half that exerted by the live steam in chamber *L*; it then exerts sufficient force on the end *n* and surface *z* of the sleeve to overcome the force exerted on the shoulder *g*, and the sleeve, consequently, is moved forwards on the stem *s* until it closes the passageway between the chambers *L* and *R*, as shown in Fig. 12, and cuts off the supply of live steam from chamber *R*. A reduction of pressure in chamber *R* again causes the reducing valve to move into the position shown in Fig. 11. Thus, by opening and closing the passage between chambers *L* and *R*, as described, the reducing valve maintains a pressure in the chamber *R* that is about four-tenths that of the live steam in chamber *L*; hence, the pressure of the steam used in the low-pressure cylinder, when the engine is working simple, is about four-tenths that used in the high-pressure cylinder, this ratio of pressure being maintained in order to make the total force exerted on the high-pressure and low-pressure pistons equal, the area of the latter piston being made two and one-half times the area of the former.

## OPERATION

**19. Working Compound.**—Assume that the locomotive is to be started as a compound engine. When the throttle is opened, steam flows into the high-pressure steam chest, and thence into one end of the high-pressure cylinder; at the same time steam flows into chamber *L*, opens the reducing valve, and closes the intercepting valve, and then passes on to the low-pressure steam chest and cylinder. Therefore, in starting compound, both the high-pressure and the low-pressure cylinders, for a few seconds, receive steam directly from the boiler; the live steam for the low-pressure cylinder, however, is reduced by the reducing valve to the required pressure. As the locomotive moves forwards, the high-pressure cylinder exhausts into the receiver at every revolution

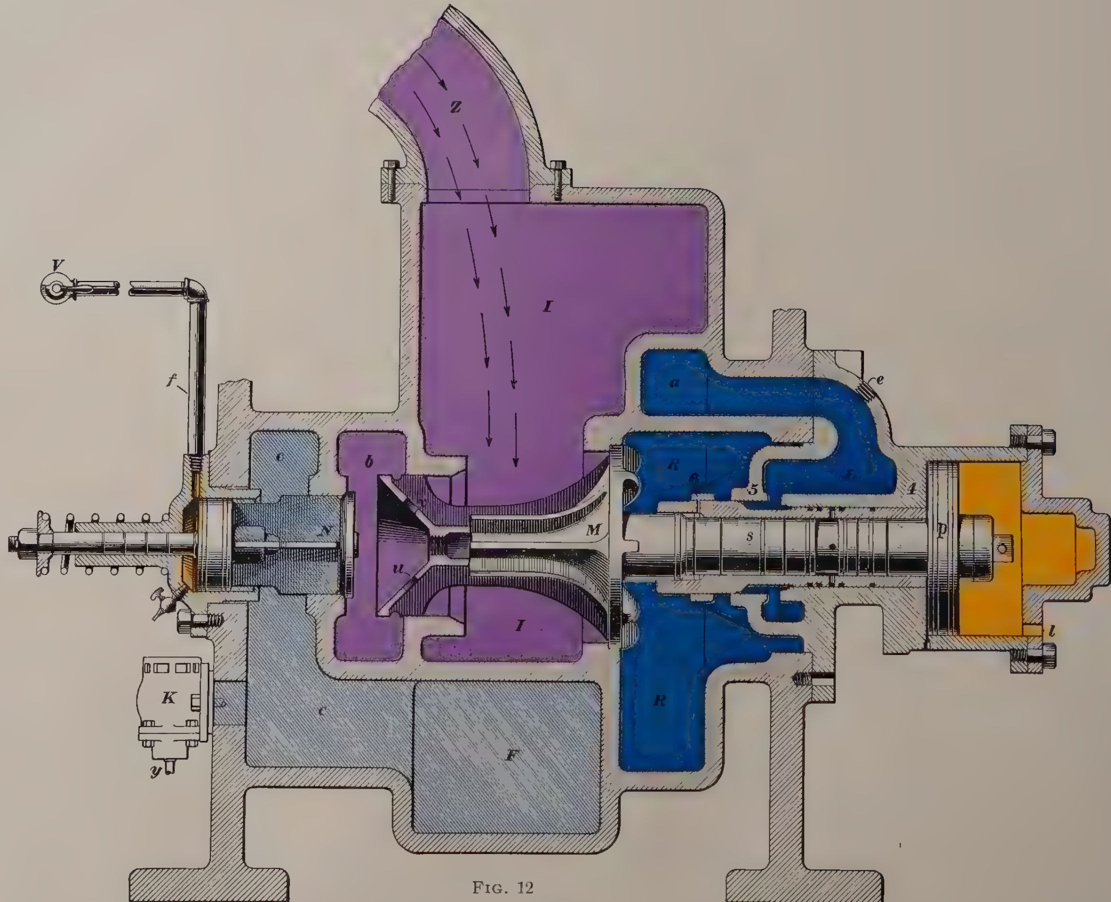



FIG. 12

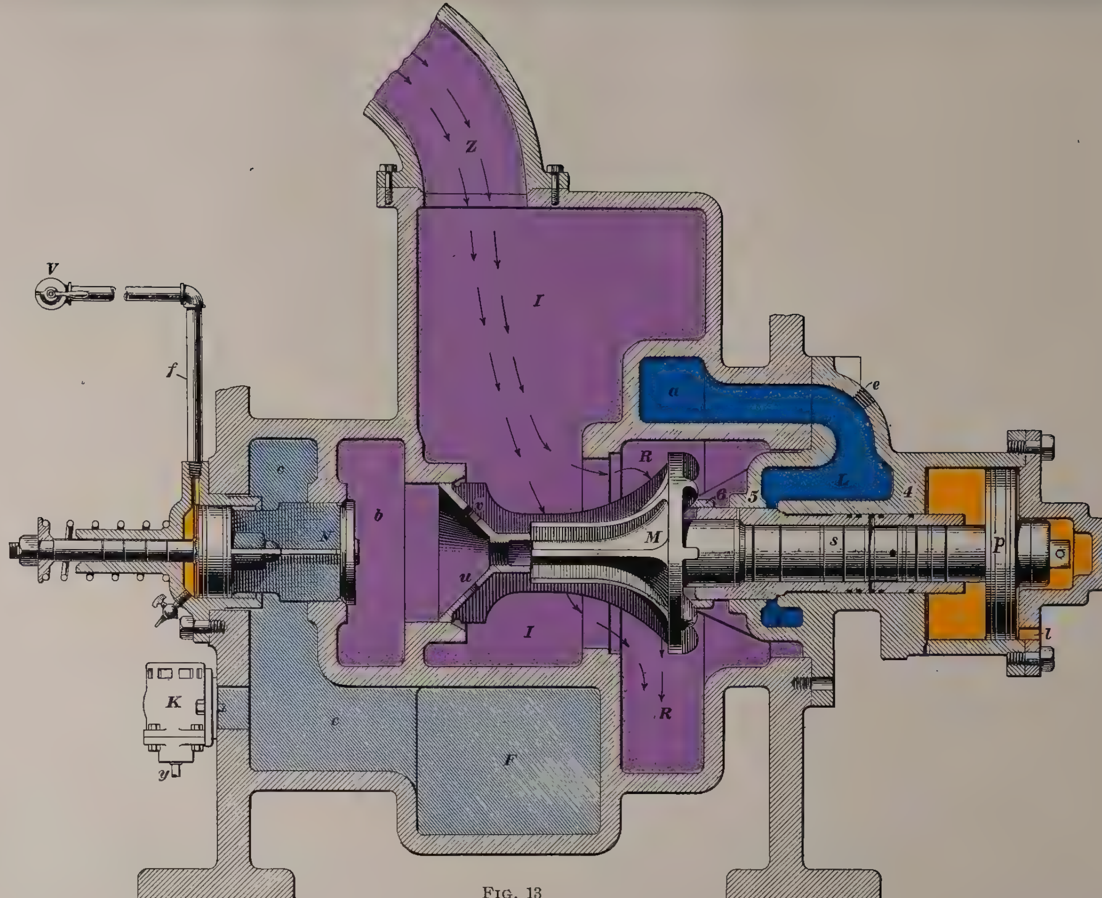



FIG. 13

of the drivers, and, since the intercepting valve is closed, the exhaust steam accumulates and raises the pressure in the receiver, until, after three or four exhausts, the pressure has increased sufficiently to force the intercepting and the reducing valves forwards to their compound positions, as shown in Fig. 13. Closing the reducing valve cuts off the live steam from the low-pressure cylinder, and this cylinder is then supplied with exhaust steam from the receiver, the steam passing through the intercepting valve to the low-pressure steam chest. It will thus be seen that, when starting the locomotive in compound position, it works as a simple engine for two or three revolutions, and then automatically changes to compound.

From the foregoing, it will be seen that the valves are wholly automatic in their action during the time the engine is working compound; that is, in starting the locomotive, the reducing valve opens and the intercepting valve closes automatically, and they remain thus until the exhaust steam from the high-pressure cylinder raises the pressure in the receiver to the required amount, whereupon the intercepting valve opens and the reducing valve closes automatically. The valves are then in their compound positions, and they remain there as long as the engine is working compound. The intercepting valve is automatically closed by the pressure of the steam on the shoulder *g* of the reducing valve, as already explained. The reason it opens automatically is as follows: The front end of the valve is larger than the back end; besides, the pressure on the small end is balanced; hence, the valve is unbalanced, and any pressure in the receiver will give it a tendency to open. As the pressure in the receiver increases, this tendency increases, until, finally, it is great enough to move the valve forwards, thus opening it.

**20. Working Simple.**—It may be necessary in starting a very heavy train, or in order to avoid stalling on a grade, to work the engine simple for a time until the train is fairly under way or the danger of stalling is past, after which it should be changed to compound. To do this, however, it is

necessary that the engineer be provided with some means by which he can convert the engine from compound to simple and back again at will. In the Richmond compound this is provided for as follows: The chamber $x$, Fig. 14, back of the emergency valve $N$, is connected by means of a pipe $f$ with an operating valve $V$ situated conveniently in the cab. When the engineer wishes to work the engine simple, he turns the handle of the valve $V$ to the position marked *simple;* this admits steam through the pipe $f$ to the space $x$ back of the valve $N$, and forces the valve forwards, thus opening it.

When the valve $N$ is closed, the pressure in chamber $b$ is maintained equal to that in chamber $I$ through the two $\frac{3}{4}$-inch holes $u$, $v$; hence, while the exhaust valve $N$ is closed, the pressure on the small end of the intercepting valve $M$ is balanced. When the valve $N$ is opened, however, the pressure in chamber $b$ escapes through the valve $N$ and the passage $c$ into the main exhaust passage $F$, thus removing, practically, all the pressure from that face of the intercepting valve $M$ that is in chamber $b$. The combined pressures of the steam in chamber $I$ on the small end of the valve $M$, together with that of the steam in chamber $L$ on the shoulder $g$, Fig. 10, of the sleeve, is then great enough to overcome the pressure of the steam in chamber $I$ on the large end of the valve $M$; consequently, if the valves are not already in their simple positions, they will be moved there. When the valves have assumed their simple position, Fig. 14, live steam passes through the reducing valve and passage $R$ into the low-pressure steam chest, while the exhaust steam from the high-pressure cylinder flows directly into the atmosphere through the receiver, emergency valve $N$, emergency exhaust port $c$, the main exhaust passage $F$, and the exhaust pipe, as indicated by the arrows. As long as the handle of the operating valve is left in the position marked *simple*, steam will flow into $x$; this will hold valve $N$ open, and the engine will work as a simple engine. When the handle is turned to the position marked *compound*, the pressure in pipe $f$ and chamber $x$ is removed, and the pressure of the exhaust steam against the back head of the valve $N$, together with the

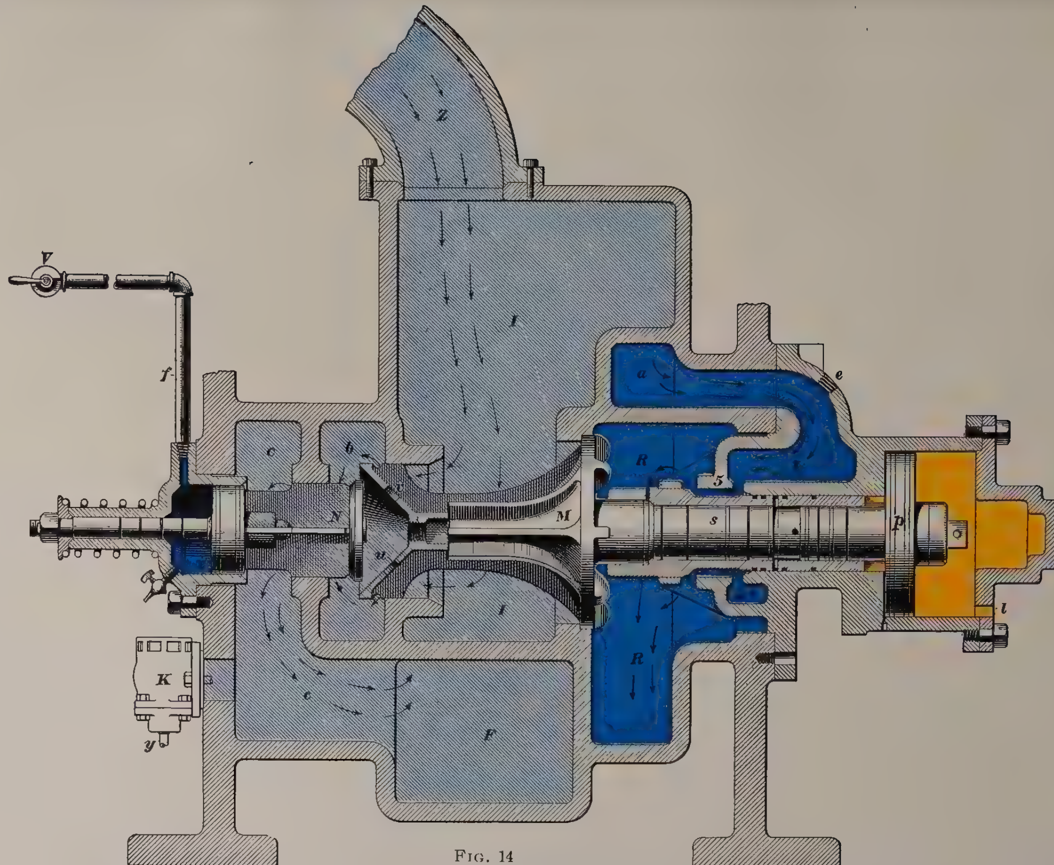



FIG. 14

action of the spring, causes the valve *N* to close. This closes the only outlet from the receiver; hence, the exhaust steam from the high-pressure cylinder raises the pressure in the receiver until it is sufficient to open the intercepting valve, and thus automatically converts the engine into a compound.

## OPERATING AND PROTECTIVE DEVICES

**21. Operating Valve.**—In Fig. 15 is given a sectional view of the **emergency operating valve** used in connection with the Richmond compound. The connection *X* is screwed into the steam turret; the pipe *f*, Fig. 14, that leads to the emergency valve, connects at *Y*, while a pipe connected to *Z* leads to the atmosphere. The double-seated valve *V* is operated by means of the handle *H* and is moved from one of its seats to the other by a half turn of the handle. The operating valve is usually so placed on the turret that the engine is working compound when the handle points to the front, and is working simple when the handle points to the rear. The tapped hole *O* ($\frac{1}{4}$-inch pipe) is for a small oil cup.

The valve operates as follows: When the handle points to the front, as in the figure, the valve *V* is in the position shown, in which position the chamber *x* and pipe *f*, Fig. 14, are open to the atmosphere through the opening of the valve *V* and the connection *Z*. This is the compound position of the operating valve. When the handle is moved so as to point to the rear, the valve *V* is raised to its upper seat, thus closing the valve opening to connection *Z* and opening that to connection *X*. Steam can now flow from the boiler through *X*, past valve *V*, out at *Y* into the pipe *f*, and so into the chamber *x* back of the emergency valve *N*, thus opening the valve and causing the engine to work simple.

**22. Overpass Valves.**—Considerable trouble has been experienced with compound locomotives on account of the action they have on the fire when drifting down grade with steam shut off. While this trouble is present to a small extent in engines having small cylinders, it is especially

noticeable in compounds in which the large low-pressure cylinder is connected directly with the exhaust. When drifting, the air drawn into the cylinders through the relief valves is compressed by the pistons, which act as air compressors, and causes thumping and rough riding of the engine; also,

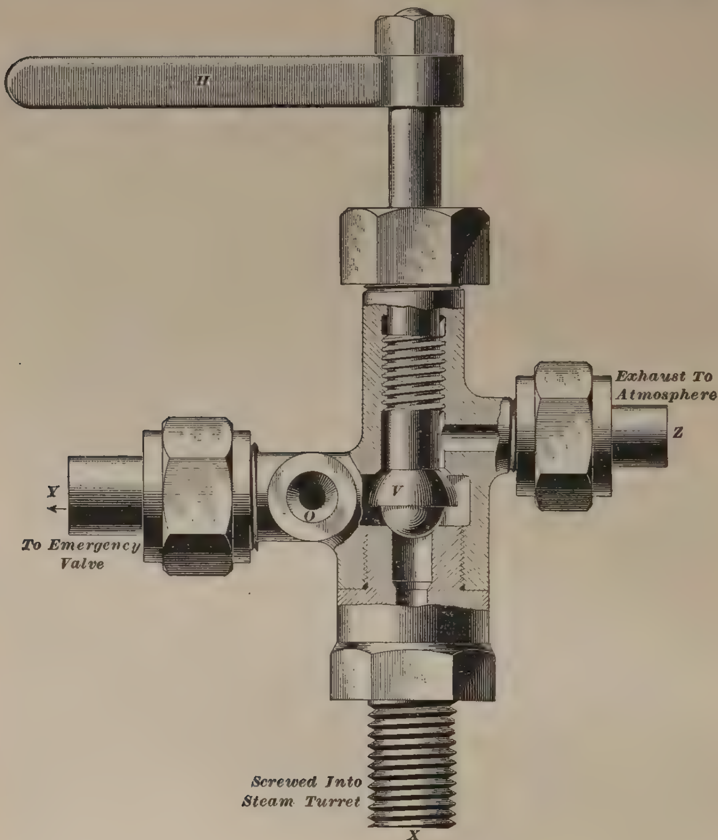



FIG. 15

the cylinders are cooled considerably by the air drawn in, and, after being compressed, the air is discharged through the stack and creates a draft that causes the fire to burn more than is desirable. The **overpass valves** of the Richmond compound were designed to prevent these evils. They are

placed together within a special chamber *W*, Fig. 7, made in the cylinder casting, just below the steam chest.

Sectional views of the overpass valves are given in Fig. 16 (*a*) and (*b*), in which (*a*) shows the position of the valves when steam is being used, and (*b*) shows the position of the valves when the locomotive is drifting with steam shut off. Fig. 16 is not a strictly accurate section of the parts and passages shown, but is so constructed as to show in effect just what the connections are. Referring to the figure, *a* and *b* represent the steam passages that lead from the slide-valve

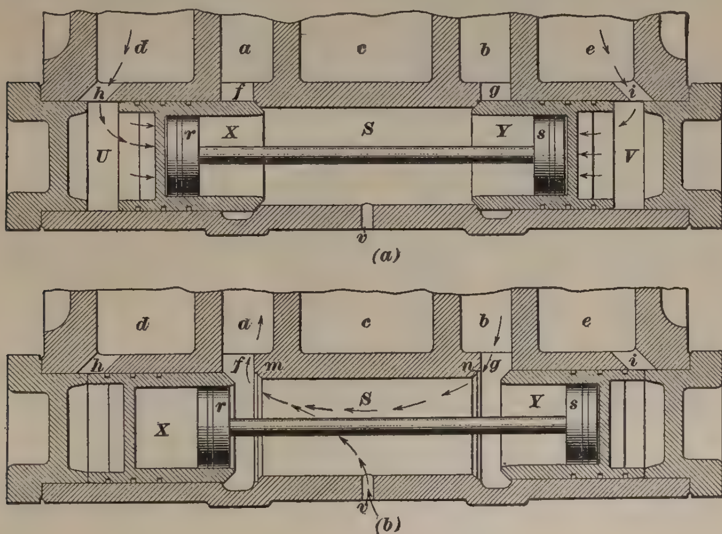



Fig. 16

seat to the two ends of the low-pressure cylinder, *c* represents the chamber connecting with the exhaust passage *F*, Fig. 14, while *d* and *e* are passages connecting with the supply ports in the steam chest. The space *S* between the valves *X*, *Y* is connected with the steam passages *a* and *b* by the ports *f* and *g*, respectively. The spaces *U* and *V* are connected with the passages *d* and *e* by means of the ports *h* and *i*, respectively. The edge of the inner faces of the valves *X* and *Y* are beveled so as to make a steam-tight joint with the seats *m* and *n*. The two pistons *r*, *s* are necessary to cushion the

movements of the valves *U*, *V* and prevent slamming, for these valves (sometimes made 5 inches in diameter) have a rapid motion.

The operation of the valves is as follows: As long as the throttle is open, the passages *d* and *e*, and, consequently, the chambers *U* and *V*, are filled with steam and the over-pass valves are held closed, as shown in view (*a*); when the

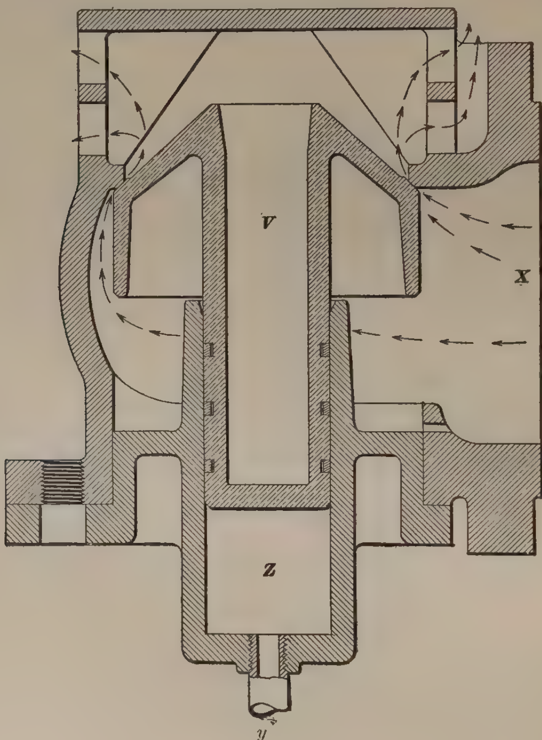



FIG. 17

throttle is closed, however, and the locomotive is allowed to drift, a vacuum forms in the steam chest. This causes a vacuum to form in chambers *U* and *V*, and the valves *X* and *Y* are forced apart by air pressure in *S*, into the positions shown in view (*b*). This opens a passage from one end of the cylinder to the other, so that the air that is being

compressed ahead of the piston is free to flow into the other end of the cylinder, as shown by the arrows, thus preventing, to a considerable extent, the formation of a vacuum there. The space *S* between the valves is connected to the atmosphere through the small vent *v*, as it was found advisable to admit some external air in order to prevent the cylinder from becoming overheated by the heat generated in churning the air back and forth in the cylinder. Also, the vent helps to prevent a vacuum from being formed. The overpass valves are only applied to the low-pressure cylinder.

**23. Automatic Air-Discharge Valve.**—A sectional view of the air-discharge valve *K*, Fig. 11, is shown in Fig. 17. As will be seen, the stem on the valve *V* is provided with three packing rings to make it steam-tight. The pipe *y* connects with the live-steam passage that leads to the low-pressure steam chest, so that there is direct connection between that steam chest and chamber *Z*. The chamber *X* is in direct connection with the exhaust passage *c*, Fig. 14. The action of the valve is as follows: Chamber *Z* is filled with steam as long as the throttle is opened, and the steam exerts a pressure on the end of the valve stem that holds the valve *V* against its seat, as shown. When the throttle is closed, however, the valve drops and a direct opening is made between the exhaust passage *c* and the atmosphere, as indicated by the arrows. Thus, when the locomotive is drifting, air can pass either from or to the low-pressure cylinder through the air-discharge valve without passing through the exhaust pipe, and the result is that the action on the fire, caused by the discharge of air from the cylinder through the exhaust pipe, is very much modified, while sparks and hot gases are prevented from being drawn into the cylinder.

## OPERATING

**24. Starting a Train.**—Under ordinary conditions, a Richmond compound will start a train of moderate weight with the operating valve in the compound position; so to start such a train, place the reverse lever in the corner, turn

the handle of the operating valve so that it points toward the front end (compound position), open the cylinder cocks, and, last of all, open the throttle; gradually hook up the reverse lever as the speed of the train increases, until it is in the proper running notch.

In starting on grades or in starting a heavy train, the engine should be worked simple until it has the train moving freely, when it should be worked compound. In other words, to start on a heavy grade or to start a heavy train, place the reverse lever in the corner, open the cylinder cocks, move the handle of the operating valve to simple position (pointing to the rear) to hold open exhaust valve *N* and then open the throttle. As soon as the train is moving freely, and it is possible to work the engine compound, do so, hooking up the reverse lever as the speed of the train warrants, until it is in the proper position.

**25. Use of Operating Valve.**—The engine should be worked simple only when it is absolutely necessary, as in the cases just cited, or when in danger of stalling, and it should be converted to compound again as soon as practicable, since the economy of the locomotive is very much reduced when working simple, and, besides, the exhaust has a very severe action on the fire at such times. It should be remembered that the reverse lever must first be placed in the corner before the operating valve is moved to simple position, and that the lever must remain in the corner as long as the operating valve remains in simple position, the handle of the operating valve always being moved to compound position before the reverse lever is hooked up. Also, the operating valve should only be used at speeds of less than 8 miles per hour.

**26. Reverse Lever and Throttle.**—When using the reverse lever, it must be remembered that the best position of the lever for a compound is somewhere between that of half cut-off and the corner, the exact notch depending, of course, on the controlling conditions, such as the load, grade, speed, etc. It must be remembered, also, that the train should be handled by means of the reverse lever rather than by the

throttle; when working compound, the lever can be dropped much lower without tearing the fire, and this should be taken advantage of when necessary. The throttle should be carried as wide open as possible under the circumstances, and the engineer should use good judgment in this respect. Under some conditions it may be found advantageous and more economical to close the throttle slightly and to drop the reverse lever a notch, rather than to run with the throttle wide open; but it should be borne in mind that the best economy will result if the throttle is always carried as wide open as the controlling conditions will permit. It is important, also, that the cylinder cocks should always be open when starting, as, at first, condensation is very rapid, especially in the high-pressure cylinder, and the resulting water greatly increases the danger of knocking out a cylinder head, should slipping occur.

**27. Drifting.**—It is very important that the reverse lever of an engine be carried near the corner when drifting with the throttle closed. The overpass valves of the Richmond type are of great service when drifting, and they should be kept in good working order. Failure of the overpass valves to operate will be manifested by a blow through the vent $v$ in the overpass valve casing, Fig. 16, when working steam, and by a disagreeable thumping when the engine is drifting with throttle closed.

**28. Oiling the Cylinders and Valves.**—One of the two cylinder feeds of the lubricator is connected to the high-pressure steam chest in the usual manner, but the oil pipe from the other feed, instead of leading to the low-pressure steam chest, is connected at $e$, Fig. 11, to the live-steam passage $a$ that leads to chamber $L$. When the locomotive is working compound, therefore, and the reducing valve is closed, it is impossible for oil to pass from the oil pipe at $e$ to the low-pressure cylinder; hence, lubrication of the cylinders at such times is accomplished by means of the high-pressure feed only, and the other feed is stopped, as any oil delivered by it will only be wasted. The feed to the high-pressure

steam chest should be set to feed from six to ten drops per minute while running under ordinary conditions, the feed being increased when the steam is wet and during such times as the locomotive is being forced.

**29.** When starting simple, allow several drops of oil to pass through the feed to the low-pressure side, so as to lubricate the intercepting valve, but shut off immediately when the engine is converted to compound. When starting compound, allow about six drops to feed to the low-pressure side. During such times as it is necessary to run the locomotive simple, reduce the feed to the high-pressure cylinder, and start the feed on the low-pressure side; the oil for the low-pressure side can then pass with the steam through the reducing valve into the low-pressure cylinder. Feeding oil into the intercepting valve is to be avoided as much as possible, since it has a tendency to gum up the small packing rings. The small oil cup that is screwed into the connection *O* of the operating valve, Fig. 15, should be filled with cylinder oil, and one cupful will provide the exhaust valve *N* with sufficient lubrication for 2 days, provided that the oil is properly used.

## BREAKDOWNS

**30. Broken Main Rod on the High-Pressure Side.** In the event of a main rod breaking on the high-pressure side, take it down, disconnect the valve rod of that side and clamp it in the center of its seat, move the piston to the back end of the cylinder, and securely block the crosshead so as to hold it there; then move the handle of the operating valve to the simple position, and run in with the low-pressure side. The low-pressure cylinder will receive live steam, at a reduced pressure, through the reducing valve, and hence will act as a simple engine.

**31. Broken Main Rod on the Low-Pressure Side.** If the broken rod is on the low-pressure side, take it down, disconnect the valve rod and clamp it in the center of its seat,, block the crosshead so that the piston will be in the

back end of the cylinder, move the operating valve to the simple position, and run in with the high-pressure side. The exhaust steam from the high-pressure cylinder will escape directly to the atmosphere through the emergency exhaust passage *c*, and, while steam can enter the low-pressure steam chest through the reducing valve, it can go no farther.

**32. Broken Valve Stem.**—In the event of a valve stem breaking, cover the ports when possible and leave the main rod up. If the ports cannot be covered, the main rod must be taken down, the valve moved ahead and fastened, and the crosshead blocked ahead.

**33. Blows.**—In the Richmond compound, blows in the slide valves and piston packing are located the same as in simple engines, by operating the compound as a simple engine. If the reducing valve does not make a tight joint with the fitting *5*, Fig. 13, live steam from chamber *L* will find its way into the low-pressure cylinder, causing a greater amount of work to be done by that side of engine than was intended, with a consequent strain of parts and loss of steam when working compound. In running along where a very light throttle is required, the exhausting steam from the high-pressure side may not have sufficient pressure to hold the intercepting valve in the compound position, so that the reducing valve will operate and allow some live steam to get into the low-pressure cylinder; when this occurs, the engine burns a great deal of coal and uses too much water. Should the emergency valve *N* not make a tight joint on its seat, the result will be that a portion of the receiver steam, which finds its way through the holes *a* and *v*, will pass by the leaky valve *N* and cause a blow at the stack between exhausts when the engine is working compound.

If the vent hole *l* in the dashpot head becomes stopped up, or the packing rings on the reducing valve leak so badly that this opening *l* cannot allow the steam to escape, the intercepting valve cannot move to the simple position even when the emergency valve is open, and it is sometimes

necessary to take off the cap and push the intercepting valve to the simple position.

In case a low-pressure steam chest is broken, or in the event of any mishap that necessitates the placing of a gasket in the joint of the small steam pipe *E*, in order to get the engine in on one side, remove the intercepting valve and force the reducing valve over against the dashpot head and secure it there, after which replace the intercepting valve, disconnect properly, as in the case of a simple engine, and with the operating valve in simple position, run in with one side.

In the event of the pipe *f* being broken so that pressure cannot be admitted to chamber *x*, Fig. 14, the emergency valve may be opened, to cause the engine to work simple, by removing the spring on the spindle, pushing the valve in by means of the rod, and fastening it there. If the large head of the valve *M* does not make a tight joint on its seat when working simple, steam will leak by to the high-pressure exhaust and will cause a poor showing in economy in coal and water.

Sometimes the reducing valve becomes stuck on the stem of the intercepting valve in such a way that it will not operate to allow live steam to flow from chamber *L* to chamber *R* in working simple, or it may be stuck in its other position so as to allow steam at boiler pressure to go into the low-pressure cylinder. To remedy this, the stem *s* should be cleaned and lubricated.

## SCHENECTADY COMPOUND

### DESCRIPTION

**34. General Arrangement.**—The general arrangement of the high-pressure cylinder *A*, low-pressure cylinder *B*, intercepting-valve chamber *C*, the steam pipes *D* and *E*, and the receiver *YZ* in the latest type of **Schenectady compound** are shown in Fig. 18. The upper part of the receiver has been broken away, to show more clearly the arrangement of the steam pipes, while the lower part

of the figure presents a sectional view of the saddle and cylinders with the steam-chest covers removed. It will be observed that the exhaust passage from the high-pressure cylinder *A* connects directly with the end *Y* of the receiver, the end *Z* of which leads to the chamber *I* surrounding the upper side of the intercepting valve. Also, it will be noticed

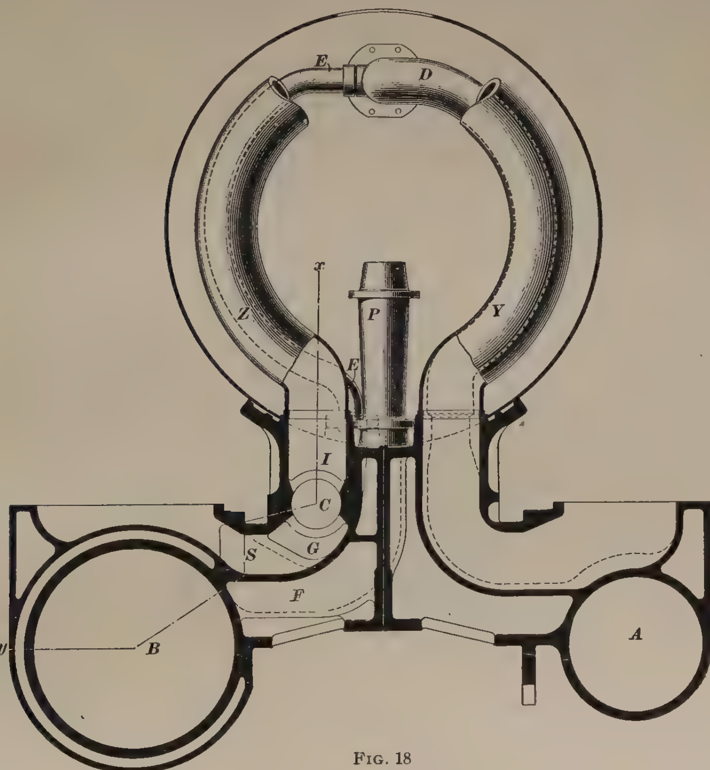


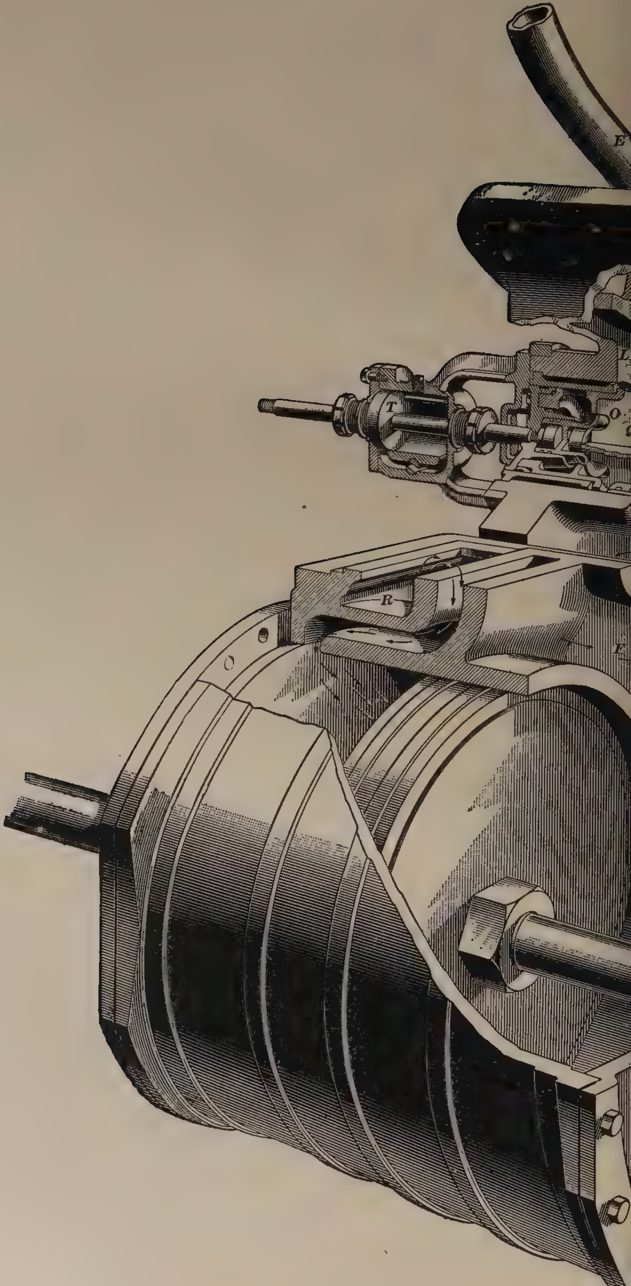

FIG. 18

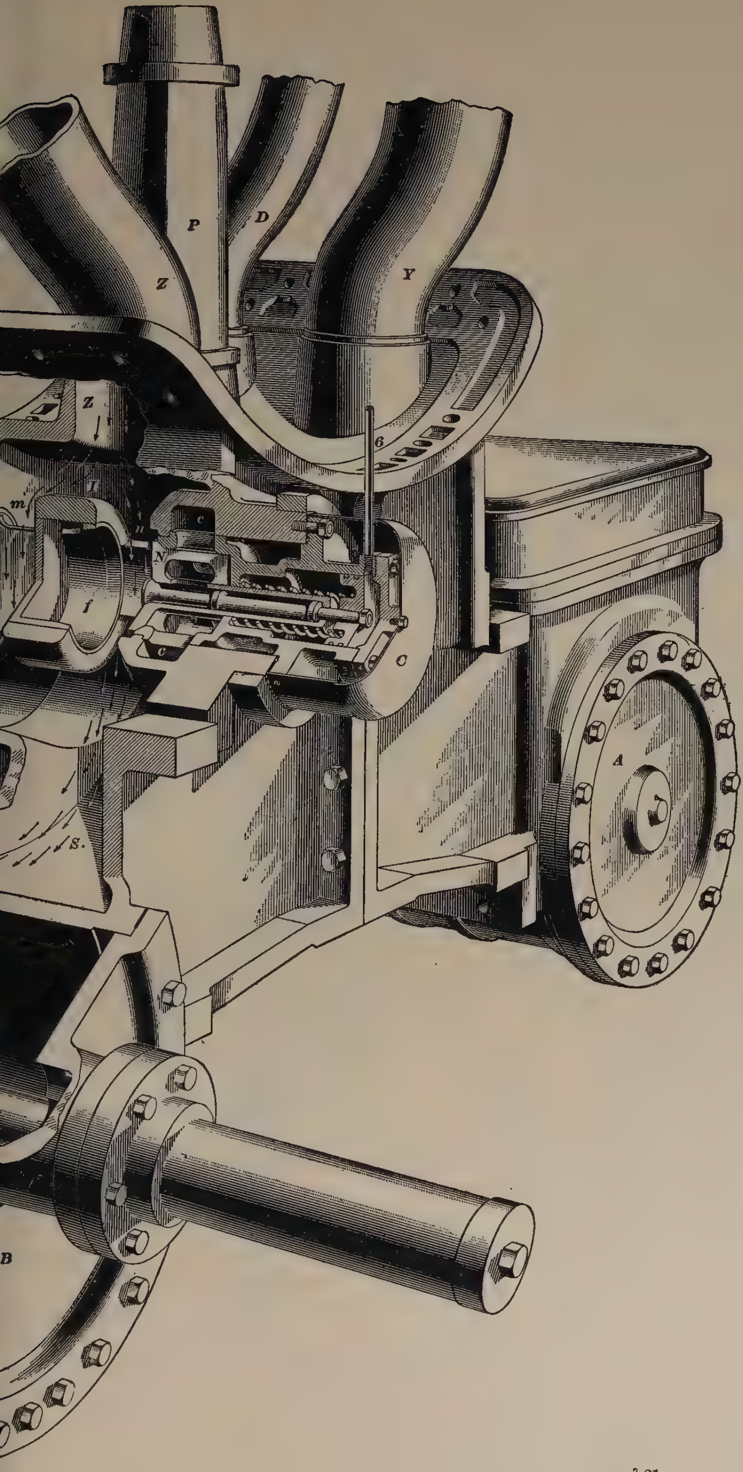
that a chamber *G* surrounds the lower side of the intercepting valve, and connects the two ends of the low-pressure steam chest by means of a divided passage—the front branch *S* of which is shown. The exhaust passage *F* from the low-pressure cylinder leads directly to the exhaust pipe *P*. The distribution of steam to the cylinders is effected by means of slide valves in the steam chests.

**35. Arrangement of Valves and Passages.**—The arrangement of the several valves of the Schenectady compound is shown in perspective in Fig. 19, part of the low-pressure cylinder and the left half of the saddle having been broken away (on the line *x y*, Fig. 18), in order to show the relative positions of the valves and passages. In the figure, *M* is the intercepting valve that controls the passages *m* and *n* leading from chamber *I* to chamber *G*. The valve *N* is the emergency exhaust valve that controls the opening from chamber *I* to the emergency exhaust passage *c*. The reducing valve *O* admits live steam at a reduced pressure into chamber *G*, and regulates the pressure there to the required amount during the time that the engine is working simple.

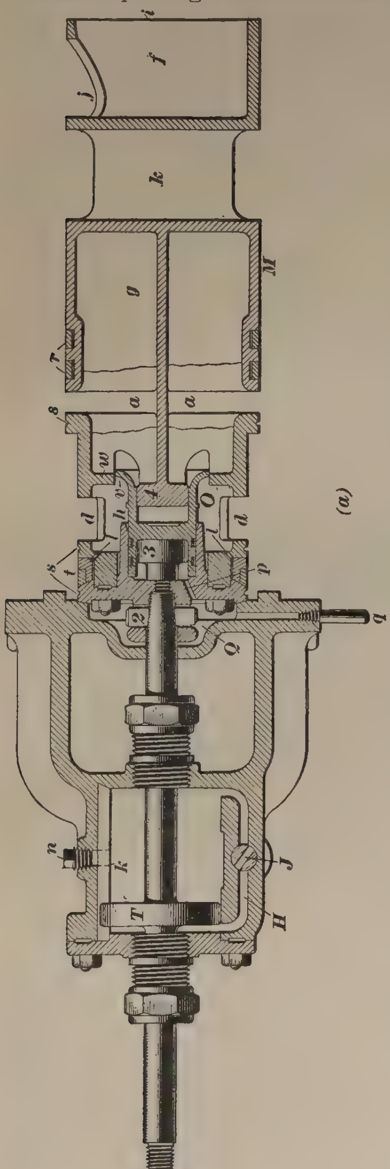
The smaller steam pipe *E* leads into a chamber *L*, which ends in another chamber that entirely surrounds one end of the intercepting-valve bushing. The chamber *e* also surrounds the intercepting-valve bushing and opens into chamber *G* on the bottom side. The chamber *c* entirely surrounds the bushing of valve *N*, and connects with the emergency exhaust passageway that leads directly into the exhaust passage *F*. The chamber *G*, as has already been stated, divides into two passages *R* and *S*, the former of which leads to the back end, and the latter to the front end, of the low-pressure steam chest. The exhaust passage *F* passes below chamber *G* and behind chamber *I*, and leads into the exhaust pipe *P*. The small pipe *6* leads to the operating valve in the cab.

**36. Intercepting Valve.**—From the sectional view given in Fig. 20 (*a*), it will be seen that the intercepting valve consists of three parts *f*, *g*, and *h*. The end *i* of part *f* is carefully finished, also a hole *j* is cut in the top of *f*, and the parts *f* and *g* are connected by a rib *k* $\frac{1}{4}$ inch thick. The second part is cylindrical also, and forms a chamber *g* into which the ports marked *a* open. Two ribs, at right angles to each other, divide chamber *g* into four compartments, and each compartment is provided with a port, the ribs being broken away in the figure to show the ports. There is a

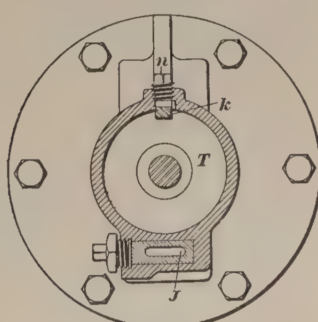

E
L
T
O
R
F


P
D
Z
Y
Z
6
I
m
n
c
N
f
C
c
C
A
S.
B

circular opening *v* in the end *w* through which the reducing valve *O* works. The third part of the intercepting valve forms a cylindrical chamber *h* having a number of ports *d* leading into it; also, it is connected with chamber *g* through the opening *v*. The second part *g* is fitted with two snap packing rings *r*, and a water-packing groove *s*, while the port *h* has water-packing grooves *s* and a packing ring *t*. Small holes *l* permit steam to flow from chamber *h* back of the ring *t*, and thus press it firmly against the valve bushing during the time that chamber *h* is filled with steam. Also, a small hole *p* connects chamber *Q* with the space back of the reducing valve *O*, while chamber *Q* is connected with the




(a)




(b)

Fig. 20

atmosphere through the drip pipe *q*. A piston *T*, the rod of which is keyed to the intercepting valve, as shown, operates in a cylinder filled with oil, and forms an oil dashpot that prevents the intercepting valve slamming. As the piston *T* moves in either direction, it compresses the oil ahead of it, and thus forces the oil through the passage *H* and the plug valve *J* into the other end of the cylinder. The rapidity with which the piston will move depends on how fast the oil can pass through the valve *J*; and the object of valve *J*, therefore, is to provide a means of regulating the movement of the piston *T*, and hence of the intercepting valve *M*. If the valve *J* is wide open, the movement of the intercepting valve will be too rapid, and the valve will slam on its seat; by turning the valve *J* gradually in the direction to close it, the movement of the intercepting valve will become slower and slower, and will entirely cease when the valve is fully closed. To allow the intercepting valve to move faster, therefore, the valve *J* should be opened a little wider; to make the movement slower, the valve *J* should be partly closed. View (*b*) is a sectional view of the oil dashpot, taken at right angles to that shown in (*a*). The plug valve *J*, it will be observed, must be turned with a wrench. The "feather" *k* extends the full length of the cylinder, and the piston *T* is cut out to receive it, so that the feather prevents the piston turning in its cylinder; and since the stem of piston *T* is keyed to the intercepting valve by the key *2*, the valve, also, is kept from turning. The oil cylinder is filled by removing the screw plug *n*; it should always be kept full of oil to prevent the intercepting valve being damaged by slamming.

**37. Reducing Valve.**—The reducing valve *O*, Fig. 20, is free to move back and forth a distance of about $\frac{3}{4}$ inch between pistons *3* and *4*. The valve is bored out to a neat fit for the piston *3*, which forms a dashpot that prevents slamming, while piston *4* acts as a guide for the valve. Two packing rings are provided to prevent the leakage of steam back of the valve, while the outlet *p* permits any steam that may leak by to escape to chamber *Q* and thence to the

atmosphere through the drip pipe *q*. Atmospheric pressure, therefore, is always maintained back of the reducing valve. Steam pressure in chamber *g* acts on the entire face of the valve *O* (*4* being only an easy fit in *O*), while the area exposed to the steam in chamber *h* is less than half as much; hence, when the pressure in chamber *g* is something less than half the pressure in chamber *h*, it will close the reducing valve. In other words, when the pressure in chamber *g* exceeds a certain percentage of that in

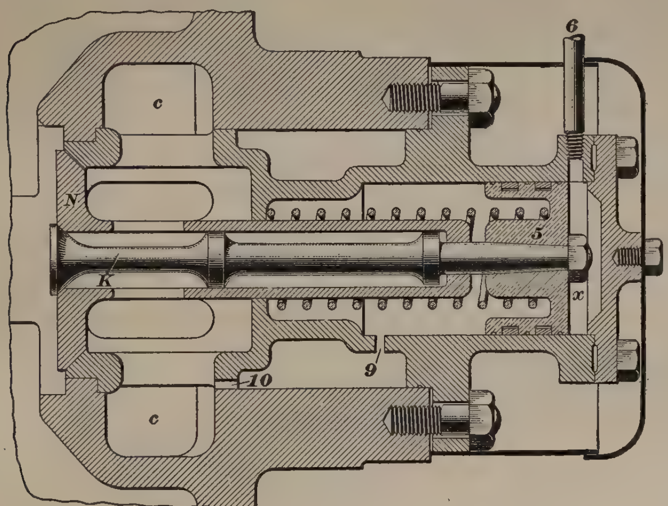



FIG. 21

chamber *h*, it will close the reducing valve; whereas, when it falls below that amount, the pressure in chamber *h* will open the reducing valve.

**38. Emergency Exhaust Valve.**—The emergency exhaust valve, Fig. 21, really consists of two valves *N*, *K* operated by the piston *5*. The chamber *x* back of the piston is connected, by means of a pipe *6*, to an operating valve conveniently situated in the engine cab; the operating valve is very similar to those already described, only in place of being piped for steam to the boiler it is piped for air to the engineer's brake valve. Sometimes, however, it is piped to both

places, in which event either air or steam can be used to operate the emergency exhaust valve.

When pressure is admitted into chamber *x*, piston *5* is pushed forwards, thus unseating the valve *K*; but the valve *N* remains closed until the piston *5* strikes *N*, when it, too, is opened. The smaller valve *K* is provided in order that the locomotive can be smoothly changed from compound to simple and without a shock while working steam with the throttle in any position. It accomplishes this as follows: During the time that the engine is working compound, the receiver is filled with steam at receiver pressure; now, if the large passage of valve *N* were suddenly opened to the exhaust, receiver pressure would quickly drop so low before the intercepting valve could move to simple position that the running gear would be subjected to severe stresses. If the small passage of valve *K* is opened to the exhaust for a few seconds before the large passage is opened, the receiver pressure will drop more gradually, and the intercepting valve will have moved to simple position and will have admitted live steam into the chamber *G* leading to the low-pressure steam chest through the reducing valve, by the time the larger passage is fully opened, so that the receiver pressure will not fluctuate much, and the engine can be changed to simple without any disturbance. The small holes *9* and *10* prevent any accumulation of pressure in the chamber ahead of piston *5*, since *10* opens directly into the emergency exhaust passage *c*.

---

### OPERATION

**39. Working Compound.**—When this type of locomotive is starting with the operating valve in the compound position, it first works live steam in both cylinders for a few revolutions of the drivers, and then automatically changes to a strictly compound locomotive as soon as the pressure in the receiver has been raised to the desired amount. The locomotive can be started compound by simply opening the throttle valve, the handle of the operating valve in the cab being left in compound position. This admits steam direct

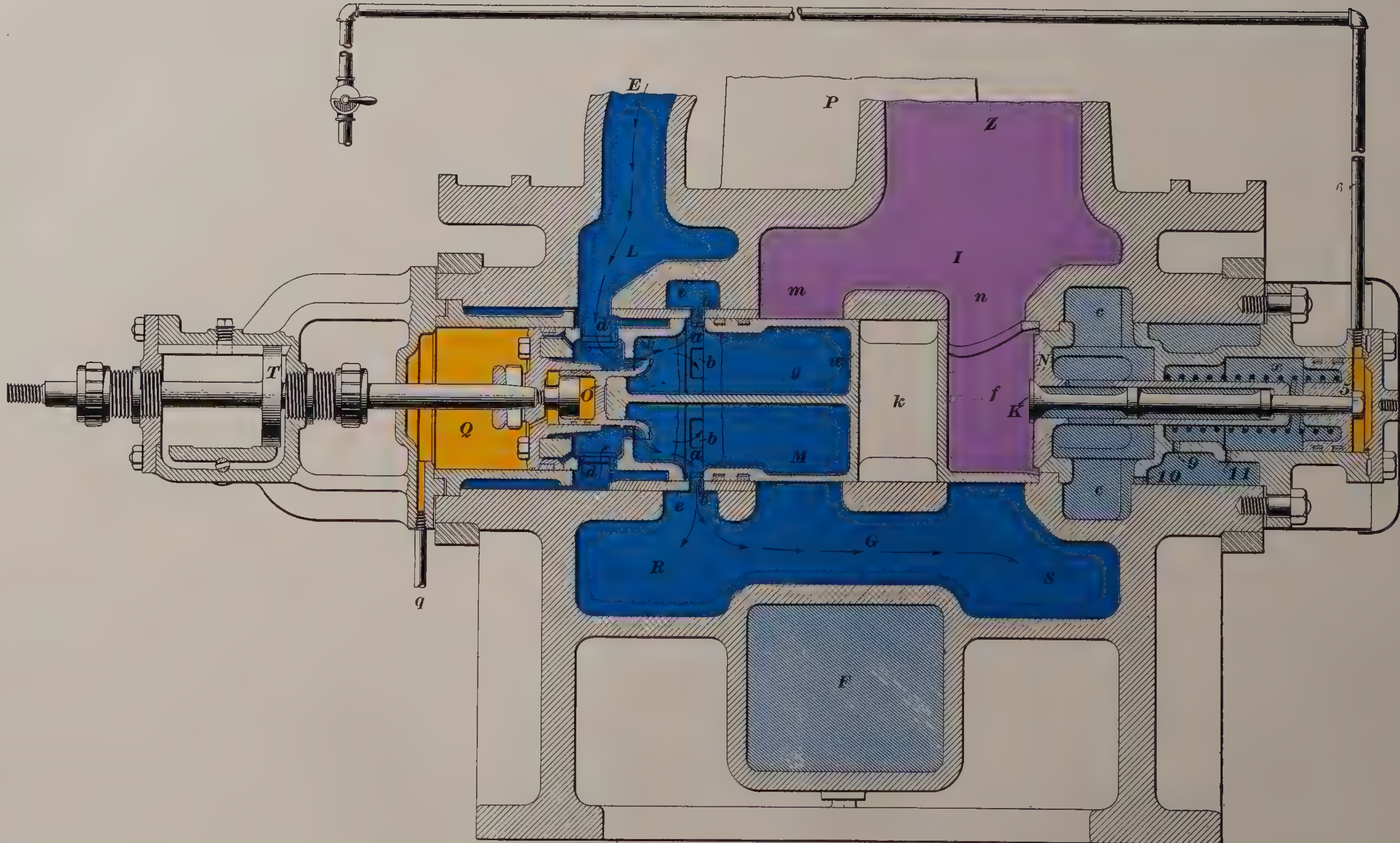



FIG. 22

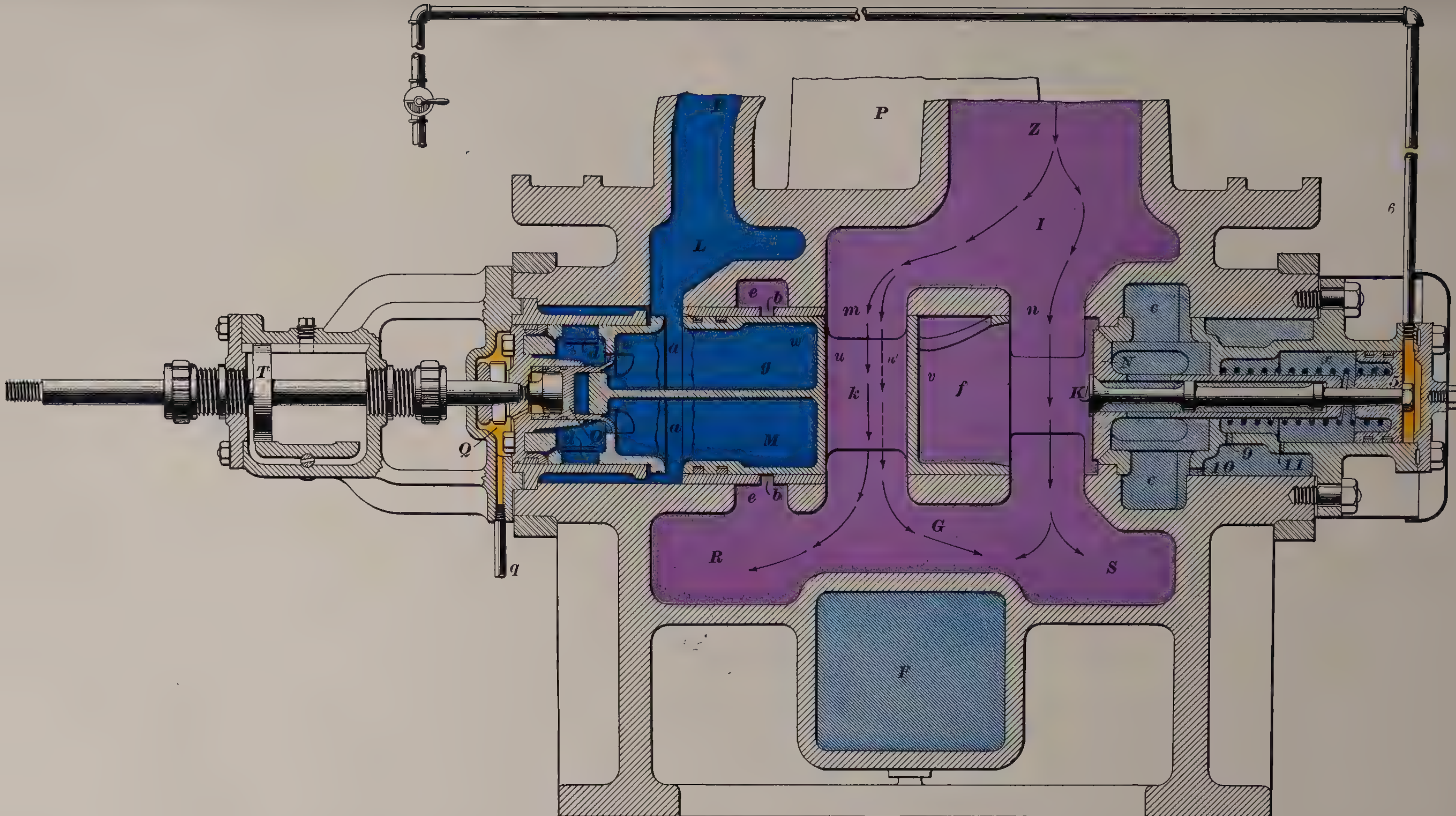



FIG. 23

from the boiler into the high-pressure steam chest through the pipe $D$, Fig. 19, and into the chamber $L$ through the small steam pipe $E$. The steam in chamber $L$ passes through port $d$ into chamber $g$ of the intercepting valve, and, on account of the greater area in the front end $w'$, forces the intercepting valve into the position shown in Fig. 22. In this position, the intercepting valve closes the passages $m, n$ that lead from chamber $I$ to chamber $G$; and, since the exhaust valve $N$ is closed, exhaust steam from the high-pressure cylinder banks up in the receiver as the locomotive moves forwards, and raises the pressure there. Also, in this position of the intercepting valve, live steam from chamber $L$ passes through port $d$, reducing valve $O$, ports $b$, through chamber $e$ into chamber $G$, whence it passes through the passages $R$ and $S$ into the two ends of the low-pressure steam chest, as indicated by the arrows. Both the high-pressure and the low-pressure cylinder, therefore, are operated for a time by live steam, although the pressure of the steam in the low-pressure cylinder is reduced by the reducing valve $O$. By the time the drivers have made two or three revolutions, the exhaust steam from the high-pressure cylinder has raised the pressure in the receiver sufficient to cause it to move the intercepting valve into the compound position, as shown in Fig. 23. The intercepting valve remains in this position as long as the engine is working compound, for the following reasons: The pressure of the steam in the receiver on the faces $u$ and $u'$ balances, and hence produces no tendency to move the valve; the pressure of the steam from chamber $L$, acting on the faces $w$ and $w'$ of chamber $g$, has a tendency to move the valve into the simple position, but this tendency is overcome by the greater pressure of the steam in the receiver acting on the face $v$ of cylinder $f$.

While the intercepting valve is in the compound position, it covers the ports $b$ in its bushing; hence, no live steam can pass from chamber $L$ into the low-pressure steam chest. The passages $m, n$ from chamber $I$, however, are now open, so that the exhaust steam from the high-pressure cylinder is

free to pass through the receiver into chamber *I*, and thence through the passages *m* and *n*, chamber *G*, and passages *R* and *S*, into the low-pressure steam chest, where it forms the supply of steam that operates the low-pressure cylinder.

**40. Working Simple.**—When the engineer desires to start the locomotive as a simple engine, he first turns the handle of the emergency operating valve to the position marked *simple*, so as to admit pressure into chamber *x*, and then opens the throttle, Fig. 24. The pressure in chamber *x* moves piston *5* and forces open the emergency exhaust valves *K* and *N*, while, by admitting steam into chamber *L*, the intercepting valve is caused to move into the simple position and to close the passages *m* and *n*; hence, the exhaust steam from the high-pressure cylinder passes through the receiver into chamber *I*, and is then obliged to pass through the exhaust valve *N* and the emergency exhaust passage *c*, into the main exhaust passage *F* and the atmosphere, as indicated by the arrows. The walls of chamber *I* are broken away to show how the passage *c* leads into the main exhaust passage *F*. The low-pressure cylinder is supplied with live steam at a reduced pressure through the reducing valve, as indicated by the arrows.

**41. Changing From Compound to Simple.**—At times, it is desirable to change the engine from compound to simple while working steam. To do this, the handle of the operating valve is merely moved to the position marked *simple*. This first causes the smaller exhaust valve *K*, and then the larger valve *N*, to open and reduce the pressure in the receiver gradually, until it is sufficiently reduced to operate the intercepting valve, thus converting the locomotive smoothly into a simple engine.

**42. Changing From Simple to Compound.**—To change the engine from simple to compound, the engineer simply moves the handle of the operating valve to the position marked *compound*. This removes the pressure from chamber *x*, Fig. 24, as will be indicated by steam or air exhausting from the exhaust port of the operating valve. In

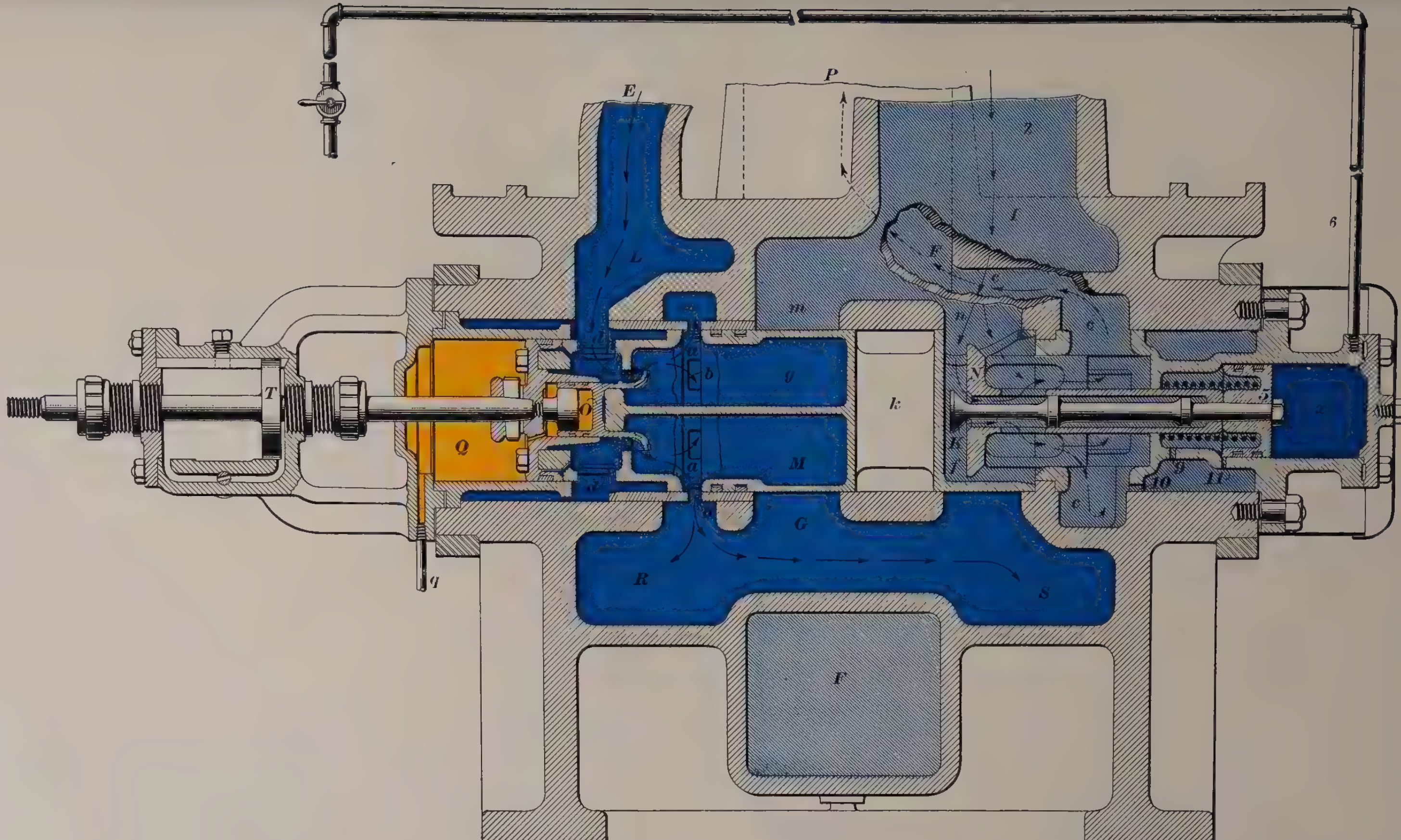



FIG. 24

case valve *N* sticks, another exhaust will be heard at the operating valve when the piston *5* is moved to its normal position by the pressure of the receiver steam. A steady blow at this exhaust indicates a leaky operating valve, or a leak of steam past piston *5* into chamber *x*. The spring *11* forces the piston *5* into its forward position, closing the emergency exhaust valve. The steam from the high-pressure exhaust then raises the pressure in the receiver until it is sufficiently high to move the intercepting valve into compound position, when the locomotive operates as a compound.

---

### OPERATING

**43. Working Compound.**—To start the locomotive compound with a light train, it is simply necessary to move the handle of the operating valve into the compound position; if not already there, place the reverse lever in the corner, open the cylinder cocks, and, lastly, open the throttle. In starting thus, live steam is admitted into both cylinders for a few moments (see Fig. 22), after which the intercepting valve automatically cuts off the supply to the low-pressure cylinder, and connects that cylinder with the receiver, from which it thereafter receives its supply. Gradually hook up the reverse lever a couple of notches at a time, as the speed increases, until the lever is in the proper running notch, and carry the throttle as wide open as circumstances will permit.

**44. Working Simple.**—In starting on a grade or in starting heavy trains, the engine should be worked simple until the train is moving freely. To start an engine simple, move the handle of the operating valve into the position marked *simple*, drop the reverse lever into the corner, open the cylinder cocks, and then open the throttle. In this way, live steam will be worked in both cylinders (see Fig. 24) until the engineer converts the engine to compound. The engine, when worked simple to start a heavy train, will jerk less and will start the train more smoothly. It should be converted to compound, however, just as soon as possible after the train is moving freely. This is accomplished by

turning the handle of the operating valve to the compound position. If the emergency exhaust valve is opened by air pressure, make sure that full air pressure is pumped up before the engine is started. After changing to compound, the reverse lever should be hooked up a few notches at a time until in the proper running notch. As with the other types of compounds, the steam supply should be controlled with the reverse lever rather than with the throttle, and the throttle should be carried as wide open as circumstances will permit; in other words, carry the reverse lever and the throttle where they will handle the train best.

---

### BREAKDOWNS

**45. Broken Main Rod on the High-Pressure Side.** In case the rod on the high-pressure side breaks, take it down, block the crosshead securely, and clamp the valve on that side in the center of its seat, so as to cover both ports; then proceed, using the low-pressure side only. As soon as the throttle is opened, the steam in chamber *L* will force open the reducing valve, and live steam at a reduced pressure will be supplied direct to the low-pressure side. Proceed the same in case of a broken crankpin, taking down the side rods in addition to the work done for a broken main rod.

**46. Broken Main Rod on the Low-Pressure Side.** In the event of a rod breaking on this side, take it down, block the crosshead in the back end of the guides, clamp the valve in the center of its seat, and move the handle of the operating valve to simple position; proceed, using the high-pressure side only. In this way, the high-pressure side will act as a simple engine, the exhaust passing out through the emergency exhaust valve.

**47. Broken Valve Stem.**—In the event of a valve stem breaking on either side, it will be necessary to disconnect the disabled side; hence, if a valve stem breaks, proceed exactly as though the main rod on that side had broken.

**48. Broken Steam Chest.**—In the event of a broken steam chest on the low-pressure side, remove the back end of the intercepting valve and block the reducing valve shut, then run with the emergency exhaust valve open. For a broken chest on the high-pressure side, treat the case the same as a simple engine and work steam in the low pressure side by running the engine in simple position.

**49. Blows.**—In the Schenectady compound, blows in the slide valve and cylinder packing can be located in the same manner as in simple engines by working the compound simple.

When working compound, a blow of steam by the packing rings on the part *g* of the intercepting valve, Fig. 23, will allow live steam from chamber *L* to flow into chamber *G*, thus increasing the power on the low-pressure side.

The emergency exhaust valve *N* leaking, will allow receiver steam to blow into the emergency exhaust passage *c* and will be heard at the stack between exhausts when working compound.

Steam leaking by the packing rings on the reducing valve *O* will cause it to remain open when working simple if the vent pipe *q* is not kept open, thus getting boiler pressure in the low-pressure cylinder.

In case a low-pressure steam chest is broken, the engine can be brought in by using the high-pressure side as a simple engine. To do this, remove the intercepting valve and block the reducing valve in closed position, so that when the intercepting valve is replaced no steam can get into the low-pressure side with the intercepting valve in simple position.

Should the steam-supply pipe *6* to the chamber, Fig. 24, become broken, the intercepting valve can be forced into simple position by removing the head of chamber *x* and blocking the emergency exhaust valve open, in the position shown in Fig. 24. If a cross-compound engine, when given steam, will not start with the high-pressure side on the center, the trouble is usually with the reducing and intercepting valves sticking in compound position.

If the intercepting valve sticks and will not move promptly to simple position or back to compound when it should, it may be forced over by hand; it should be taken out and cleaned as soon as practicable.

## PITTSBURG COMPOUND

### DESCRIPTION

**50. General Arrangement.**—A cross-section of the cylinders and saddle of a **Pittsburg compound,** taken through the middle of the receiver $YZ$, is shown in Fig. 25,

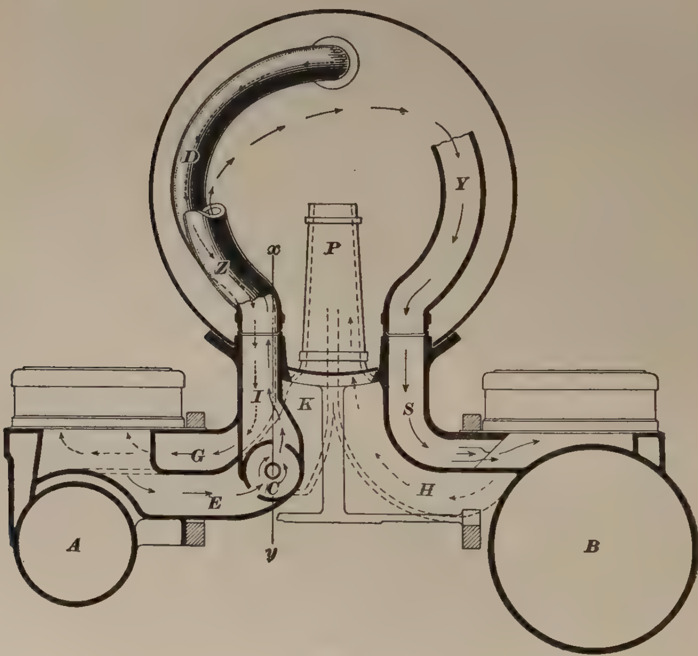



FIG. 25

in which $A$ and $B$ are the high- and low-pressure cylinders, respectively, and $C$ is the intercepting-valve chamber. In this type of compound there is but one steam pipe $D$; it connects with a passageway back of chamber $I$ (indicated

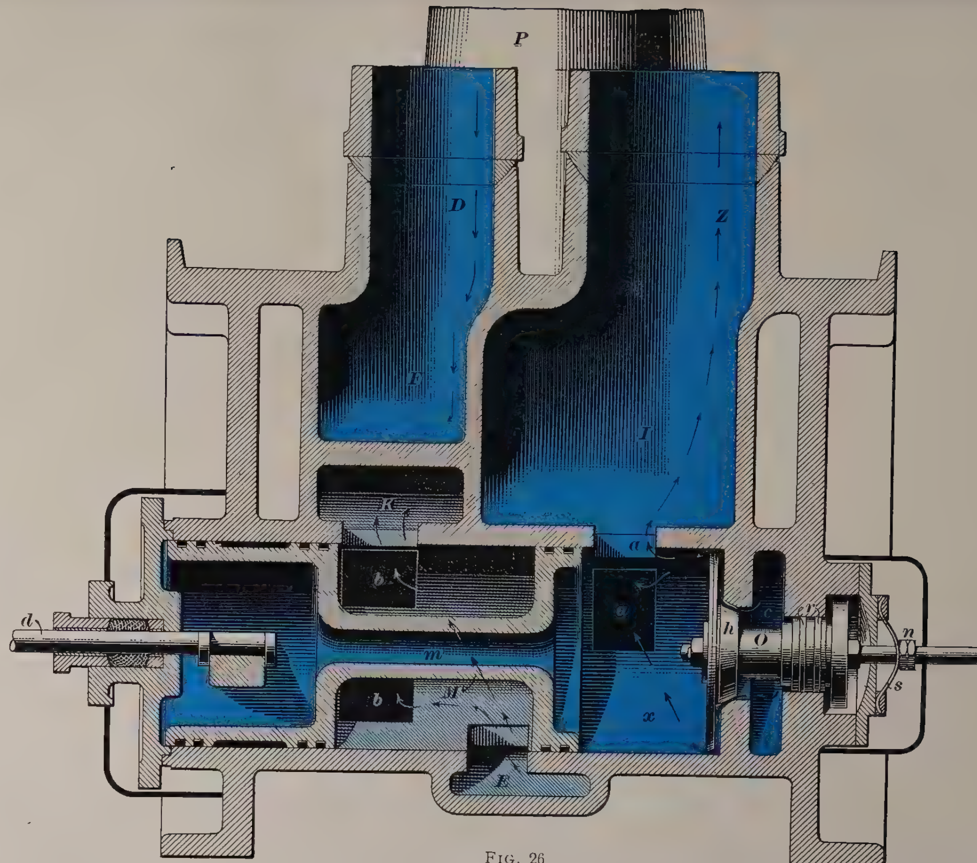



FIG. 26

by dotted lines) that divides into two branches at *G*, these branches leading to opposite ends of the steam chest. The exhaust passage *E* from the high-pressure cylinder leads to the under side of the intercepting valve in *C*, while directly above is the chamber *I* that connects with the end *Z* of the receiver. A passage *K* (indicated by dotted lines), back of the chamber *I*, connects one end of the intercepting valve with the exhaust pipe *P*. This is the emergency exhaust port through which the high-pressure steam exhausts during the time that the engine is working simple. The end *Y* of the receiver connects with a steam passage *S* that divides into two branches, which lead to opposite ends of the high-pressure steam chest. The exhaust passage *H* (indicated by dotted lines) from the low-pressure cylinder leads directly to the exhaust. When this engine is working as a compound, therefore, the exhaust steam from the high-pressure cylinder first passes through the intercepting valve, and thence, through chamber *I* and the receiver, into the low-pressure cylinder; the exhaust from the latter passes through the exhaust passage *H* directly into the atmosphere. In working simple, the exhaust from the high-pressure cylinder passes directly into the atmosphere through the emergency exhaust port *K*.

**51. Arrangement of the Valves and Passages.**—A section of the high-pressure cylinder saddle, taken on the line $xy$, Fig. 25, showing the arrangement of the different valves and passages, is given in Fig. 26. In the figure, *M* is the intercepting valve and *O* the reducing valve. The chamber *I* connects with the end *Z* of the receiver. The passageway *F* connects with the steam pipe *D* and divides into two branches *G*, as explained in connection with Fig. 25; hence, steam flows from the passage *F* directly into the two ends of the high-pressure steam chest. The passage *K* is the emergency exhaust passage, and leads into the main exhaust passage, as already explained. A short passageway connects chamber *c*, back of the reducing valve, with the steam passage *G*, shown in Fig. 25; hence, cavity *c* is

supplied with steam at the same pressure as the high-pressure steam chest.

**52. Intercepting Valve.**—This valve is in the form of a piston valve, and is so designed that it separates the ports *a* leading into chamber *I* from the ports *b* leading into the emergency exhaust passage *K*, although it can be made to connect the high-pressure exhaust port *E* with either port *a* or port *b* by simply changing its position. When the valve is in its backward position, as in Fig. 26, the cavity of the valve connects the exhaust port *E* from the high-pressure cylinder with the emergency exhaust port *K*, while, at the same time, the valve cuts off the ports *a* leading into the receiver. When in its forward position, it covers the ports *b* and connects port *E* with ports *a*. In order that the valve may be properly balanced, a passage *m* is made through it lengthwise, thus insuring the same pressure on both ends.

**53. Operation of Intercepting Valve.**—The means used to operate the intercepting valve are shown in Fig. 27. The valve spindle *d* is connected, by means of the lever *L* and rod *R*, to a reversing mechanism *N*, called the **reversing cylinder.** The object of this mechanism is to relieve the engineer of the necessity of converting the engine from simple to compound, or vice versa, by hand. A hand arrangement *H*, however, is provided for use in case of accident to the reversing cylinder. The steam for operating the reversing cylinder is supplied through the pipe *e*, and the supply is controlled by a valve operated by means of the rod *n*. This rod is so connected to the reach rod *r* that it operates a reversing valve *V*, so as to admit steam into the reversing cylinder and convert the engine into a simple one if the reverse lever is placed in either corner, or into a compound if the reverse lever is hooked up one or more notches from the corner. A stop-cock is placed in the steam pipe, so that, when desirable, steam can be entirely cut off from the reversing cylinder. Sometimes the mechanism for operating the reversing-cylinder valve is connected to the reverse lever instead of to the reach rod, as described.

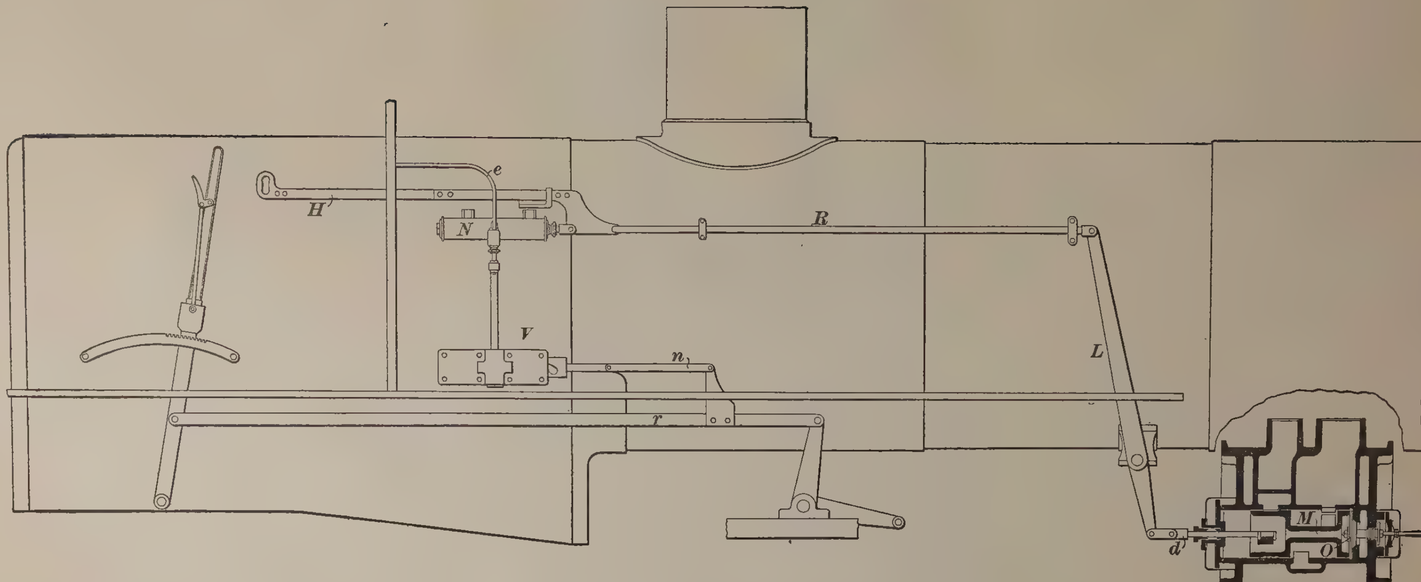



FIG. 27

**54. Reducing Valve.**—The reducing valve *O* is shown open in Fig. 26, and closed in Fig. 27. It is provided with a ground-joint seat at *h*, Fig. 26, two packing rings *r*, and a springs *s*, the tension of which is adjusted by the nuts *n*. The tension of this spring should be only sufficient to prevent the valve rattling during the time the engine is running with steam off, and the valve should be easily moved by the hand against the action of the spring. The area of the valve *O* acted on by the steam in the chamber *x*, during the time that the engine is working simple, is so much greater than that acted on by the steam in chamber *c* that the valve is closed when the pressure in chamber *x* increases to a certain proportion (sometimes less than a half) of that in chamber *c*. In other words, the reducing valve maintains a pressure in chamber *x* something less than half that in chamber *c*, thereby equalizing the total forces acting on the high-pressure and low-pressure pistons.

---

### OPERATION

**55. Working Simple.**—In this style of compound, the intercepting valve is wholly non-automatic, and it must be moved from the simple to the compound or from the compound to the simple position by means of the reversing cylinder *N* or the hand arrangement *H*, Fig. 27. So long as the reversing cylinder *N* is operative, the act of placing the reverse lever in either corner will cause the intercepting valve to be moved into the simple position (the handle *H* in its forward position); whereas, moving the reverse lever one or more notches from the corner causes the intercepting valve to be moved into compound position, the handle *H* then going to its backward position.

With the intercepting valve in the simple position, Fig. 26, the emergency exhaust port *K* is connected with the high-pressure exhaust passage *E* through the cavity of the valve *M* and the port *b*, and communication between the receiver *I* and the port *K* or *E* is cut off by the valve. When the throttle is opened, steam flows from the boiler into

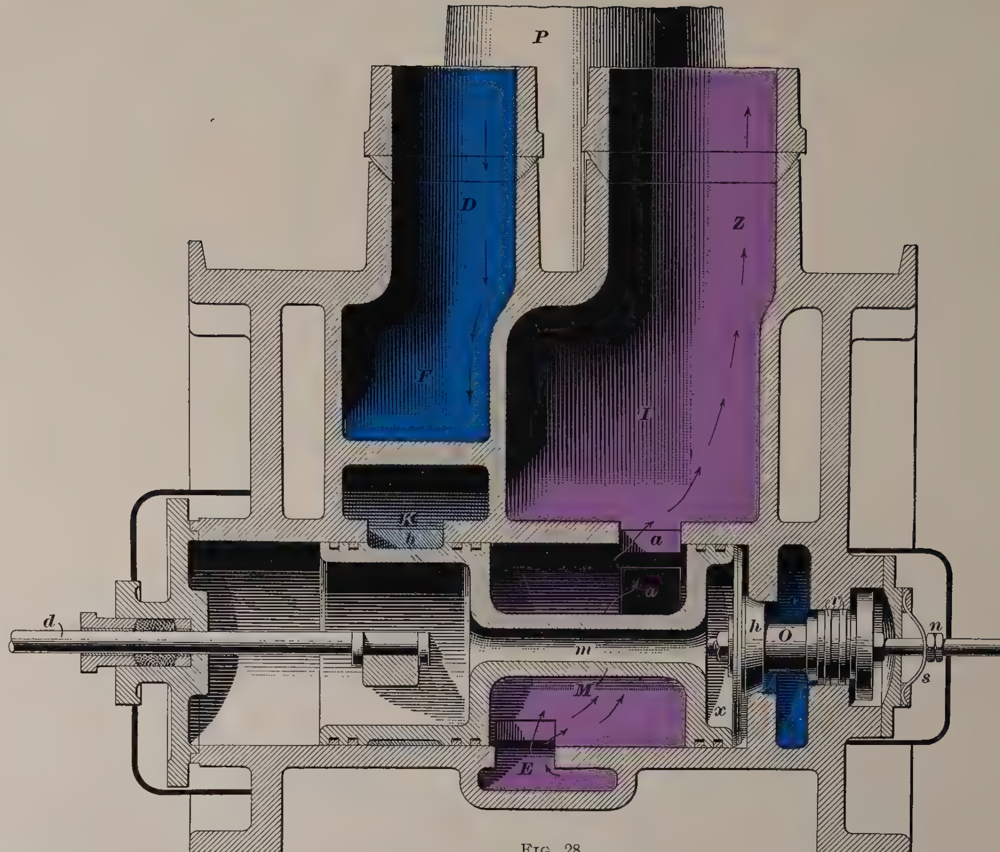


Fig. 28

the high-pressure steam chest, and also into chamber *c*. The steam in the steam chest is used in the high-pressure cylinder and is then exhausted directly into the atmosphere through the exhaust port *E*, the emergency exhaust port *K*, and the exhaust pipe *P*, as indicated by the arrows. The steam in chamber *c* opens the reducing valve *O* and flows through chamber *x* and the port *a* into the receiver (as indicated by arrows), and thence into the low-pressure steam chest; after being used in the low-pressure cylinder, it is discharged into the atmosphere through the exhaust pipe *P*. The pressure of the live steam in the receiver is regulated to the proper amount by the reducing valve *O*.

Sometimes, as, for instance, when switching, it is desirable to work the engine simple at different points of cut-off; that is, with the reverse lever in notches other than the corner notch. To accomplish this, first place the reverse lever in the corner, so that the intercepting valve will be moved into the simple position, and then close the stop-cock (not shown in Fig. 27) in the reversing-cylinder supply pipe *e*, so as to cut off the supply of steam to the reversing cylinder; the intercepting valve will then remain in the simple position, regardless of the position of the reverse lever. Opening the stop-cock in the supply pipe will again make the reversing cylinder operative.

**56. Working Compound.**—When the intercepting valve is moved into the compound position, Fig. 28, the port *b* leading into the emergency exhaust passage *K* is covered by the valve, and the high-pressure exhaust port *E* is connected with the receiver through the cavity *M* of the valve and ports *a*. Also, the reducing valve *O* is held closed. Therefore, when the throttle is open with the intercepting valve in this position, the exhaust steam from the high-pressure cylinder passes through the intercepting valve and into the receiver, as indicated by the arrows, thence passing through the receiver into the low-pressure cylinder, and out into the atmosphere through the exhaust passage *H* (Fig. 25) and the exhaust pipe.

## OPERATING

**57. Working Compound.**—To start a train with a Pittsburg compound, the engine should always be converted into a simple one until the train is fairly under way, when it should be changed to compound. To do this, place the lever in the corner (which converts the engine to simple), open the cylinder cocks, and then open the throttle. By the time the train has moved three or four car lengths, hook the lever up a notch or two (which converts the engine to compound), and, as the speed increases, continue to hook it up until it is in the proper running notch. No attempt should be made to run with the lever notched up higher than the fourth notch, since doing so will cause increased loss through condensation in the cylinders. The throttle should be carried as wide open as is possible under the circumstances.

**58. Working Simple.**—At times, especially when switching, it is desirable to work the engine simple, and yet be able to carry the reverse lever in different notches; in other words, it is desirable at times to use the engine strictly as a simple engine. This may be done by first moving the reverse lever to the corner and then closing the stop-cock in the steam pipe to the reversing cylinder; the locomotive can then be operated as a simple engine as long as desired, and with the reverse lever in any notch. The engine should always be changed to simple when drifting with steam shut off; or, if not convenient to do so, the throttle should be opened a "crack," so as to admit just enough steam into the cylinders to prevent the formation of a vacuum.

**59. Changing From Compound to Simple.**—Sometimes when climbing grades, it is found necessary to convert the locomotive from compound to simple to avoid being stalled. At such times, do not make the change unless it is strictly necessary and the speed has decreased to less than 6 miles an hour, and change back to compound again at the earliest moment possible. Close the throttle somewhat just before changing from compound to simple, since otherwise

the increased cylinder power is liable to cause slipping before the throttle can be closed sufficiently to prevent it.

**60. Care of Engine.**—The high-pressure cylinder requires a great deal more oil than the low-pressure cylinder; in fact, the low-pressure cylinder should only receive one drop to every five or six drops for the high-pressure cylinder. Fill the reducing-valve oil cup each trip, and oil the back end of the intercepting valve at least once a week. The operating mechanism of this compound is so constructed that it should convert the engine to simple by placing the reverse lever in the corner, and to compound by moving the lever one or two notches from the corner; if it does not do this, report the facts at once.

## BREAKDOWNS

**61. Broken Main Rod on the High-Pressure Side.** If the rod on the high-pressure side breaks, take it down, block the crosshead securely, place the steam valve of that side on the center of its seat and clamp it there, move the intercepting valve to simple position, and close the stop-cock so as to cut out the reversing cylinder, thus enabling the locomotive to be operated as a strictly simple engine; proceed, using the low-pressure cylinder only. Live steam will thus be supplied to the low-pressure cylinder through the reducing valve and the receiver.

**62. Broken Main Rod on the Low-Pressure Side.** In the event of this rod breaking, move the reverse lever to the corner to convert the engine to a simple one, and close the stop-cock in the steam pipe to the reversing cylinder, so that the engine can be worked simple. Take down the broken rod, block the crosshead securely, place a piece of wood under each side of the reducing-valve spring *s*, Fig. 26, and tighten up the nuts *n* until the spring pinches the wood sufficiently hard to hold the reducing valve shut against the pressure of the steam in chamber *c*; proceed, using the high-pressure cylinder only. By thus clamping the reducing valve

shut, steam is prevented from entering the receiver; hence, the low-pressure steam valve need not be clamped on the center of its seat.

**63. Broken Valve Stem.**—In the event of a valve stem breaking, proceed exactly as you would were the main rod on that side to break.

**64. Blows.**—Blows in the slide valves and piston packing of the Pittsburg compound are located as in a simple engine when the compound is worked as a simple engine.

A leak by the packing rings on the large head of the intercepting valve *M*, when in compound position, Fig. 28, will allow steam to flow by and condense in the chamber behind it if the vent (not shown in cut) is not kept open. The result of this is that when the engine is changed to simple the water will pass through the hollow *m* of the valve *M*, and will be thrown out with the exhaust from the low-pressure side; it will pass into the low-pressure steam chest with the live steam coming through the reducing valve *O*. The construction and arrangement of the intercepting and reducing valves of this type of compound give very little chance for trouble from defective packing rings or other leaks.

# TANDEM AND BALANCED COMPOUND LOCOMOTIVES

## TANDEM COMPOUND LOCOMOTIVES

### SCHENECTADY TANDEM COMPOUND

#### DESCRIPTION

**1. General Arrangement.—Tandem compound locomotives** differ from simple locomotives only in the number of cylinders used and in the arrangement of the cylinder saddles due to the increased number of cylinders. The low-pressure cylinders are in the same positions as the cylinders of a simple engine, and the high-pressure cylinders are in line with, and just forward of them, the pistons for both cylinders being on the same rod. Tandem compounds have no receiver pipes in the front end, so the smokebox is fitted up with the same arrangement of steam pipes and exhaust pipes as a simple engine. The valve chest is common for both the high-pressure and low-pressure valves, and serves the purpose of a receiver for this type of engine.

A tandem compound built by the American Locomotive Company is shown in Fig. 1, from which the arrangement of the cylinders can be seen. A view of the cylinders and saddles is also given in Fig. 2; one half shows a sectional view of the low-pressure cylinder *3*, steam chest or receiver *R*, exhaust passage *E*, and steam passage *S*; the other half is a front view. The passage *s* leads into the steam passage *S* and thence into the high-pressure cylinder

FIG. 1

through a short pipe, not shown in Fig. 1, that connects with the cylinder at *X*. This is the steam passage for the high-pressure cylinder. It is cored through from end to end of the saddle to make the cylinders interchangeable, so that

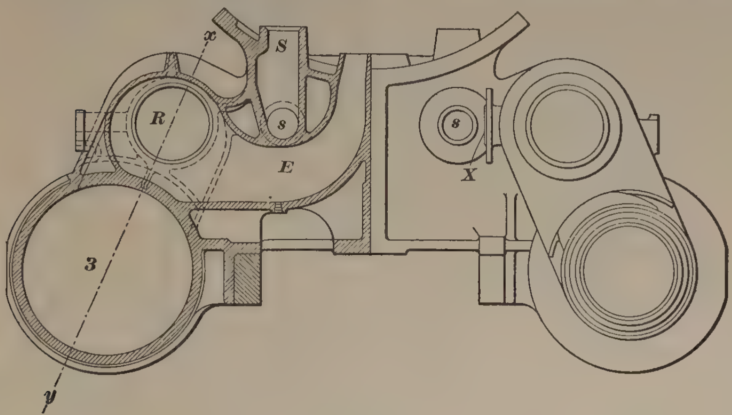



FIG. 2

they can be used for either side of the engine. The low-pressure cylinder is cast with the saddle; the high-pressure cylinder is cast separate and mounted on the front face of the low-pressure cylinder with only a single head between, as shown in Fig. 3.

**2. Arrangement of Valves and Passages.**—A sectional view of the cylinders and valves, taken on the line *x y*, Fig. 2, is shown in Fig. 3, in which *1* and *2* are the high-pressure cylinder and piston, respectively; *3* and *4*, the low-pressure cylinder and piston; and *5* and *6*, the high-pressure and low-pressure valves. Both valves are hollow and fitted to the same valve stem. Steam enters the steam chest at *S*, through the pipe connection *X*, Fig. 2.

In order to use but one valve stem and to avoid the use of a rocker to reverse the motion of the high-pressure valve *5*, or a double-ported valve for the low-pressure valve *6*, the present arrangement of valves and steam passages was adopted. This consists in using an outside admission valve *6* for the low-pressure cylinder, and an inside admission valve *5*,

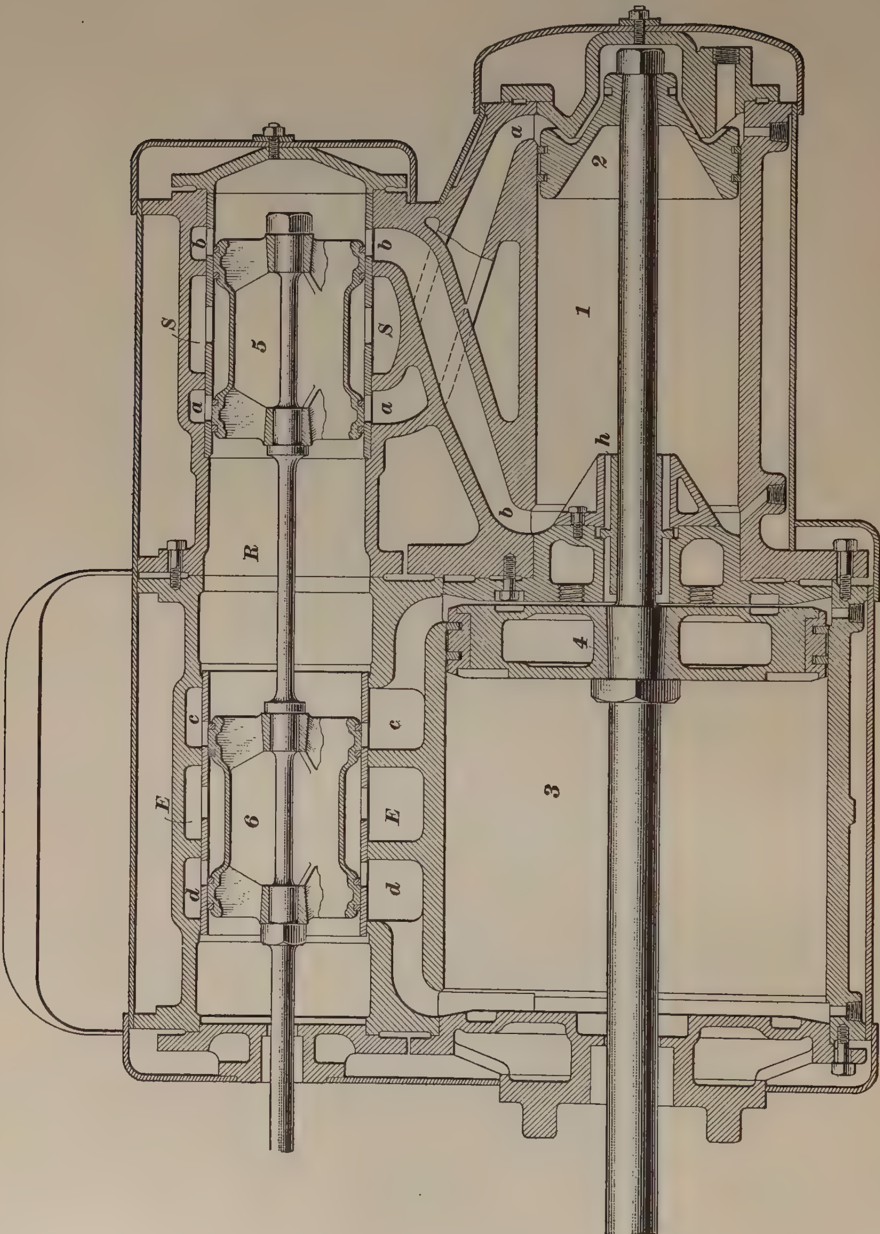



FIG. 3

with the steam ports *a* and *b* for the high-pressure cylinder crossed as shown. Crossing ports *a* and *b* increases the clearance of the high-pressure cylinder, which is a benefit to the high-pressure cylinder as it reduces excessive compression.

Both pistons are on the same piston rod, as shown. The piston-rod packing between the cylinders consists of a close-fitting sleeve *h* with water grooves on the inside face. It has a collar with ground joints that fits loosely enough between the cylinder head and the gland to accommodate the movement of the piston rod and any wear on the pistons and cylinders. The collar is held steam-tight against the cylinder head by the pressure of the steam in cylinder *1*.

**3. Low-Pressure By-Pass Valves.**—By-pass valves for relieving the cylinders of back pressure when drifting, are provided for both the low-pressure and high-pressure cylinders. Those for the low-pressure cylinder are bolted to the side of the steam chest just above, and near the ends of the low-pressure cylinder, as shown in Fig. 1, and when open provide direct communication between the receiver *R* and the steam ports *c* and *d* to the two ends of the cylinder, as shown in Fig. 6. They are illustrated in Fig. 4, in which (*a*) is a side view, and (*b*) and (*c*) sectional views taken on the line *x y*, view (*a*). When bolted to the steam chest, port *x* of each by-pass valve connects with a passage that opens into the receiver *R*, while port *y* of each by-pass valve connects with a passage that opens into the steam port to the end of the cylinder on which the by-pass is located. This is shown diagrammatically in Fig. 6.

**4. Operation of Valve.**—When the throttle is closed and there is no steam in the steam chest, spring *s* of the by-pass valve holds valve *V* open, as shown in Fig. 4 (*b*). In this position, there is direct communication between the two ends of the cylinder, as follows (see Fig. 6): Through the cylinder steam passage *d*, port *y*, valve *V*, port *x*, into the receiver *R*; thence through port *x* to the opposite by-pass valve and through valve *V*, port *y*, and the cylinder steam passage *c* into the opposite end of cylinder.

The valve *V* has two seats *a* and *b*, Fig. 4. Seat *a* prevents leakage of steam from the steam chest into the cylinder;

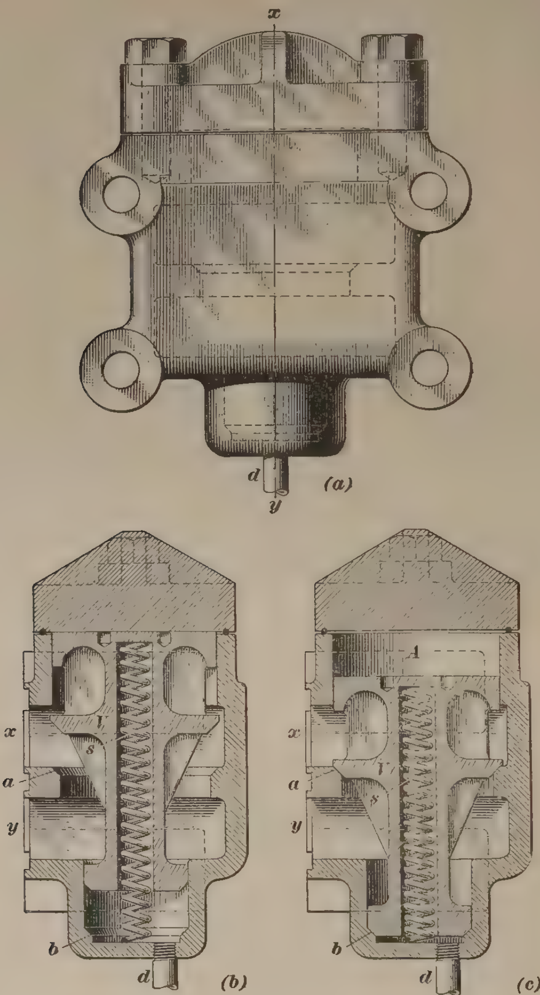


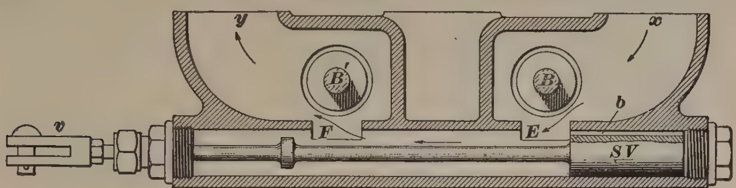

FIG. 4

seat *b* prevents steam escaping from the cylinder through the drip pipe *d* to the atmosphere. When the throttle is opened,

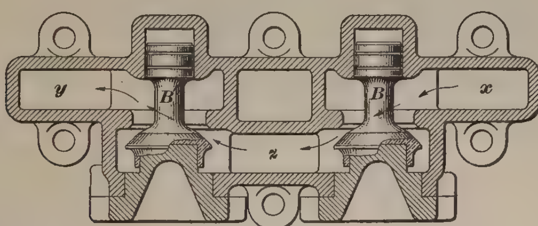
steam fills chamber $A$ and seats valve $V$, thus closing the by-pass communication between the two ends of the cylinder.

**5. High-Pressure By-Pass Valves.**—The by-pass valves for the high-pressure cylinders are contained in the same casing as the starting valves. They are secured to the side of the steam chest over the high-pressure cylinder as shown in Fig. 1, one on each side of the engine, and have direct communication with the steam passages to the high-pressure cylinder.

A horizontal and a vertical section of the starting-valve case, showing the high-pressure by-pass valves and the starting valve, is given in Fig. 5. View $(a)$ is a horizontal



(a)



(b)

FIG. 5

section and shows the by-pass valves $B$ and $B'$ and the starting valve $S\,V$. View $(b)$ is a vertical section and shows the relation of the by-pass valves to each other.

Port $x$ connects with a passage that opens into the cylinder steam port $a$, Fig. 6; port $y$, with a passage that opens into steam port $b$; and port $z$, Fig. 5, view $(b)$, with a passage that opens into the high-pressure steam supply $S$, Fig. 6. When the throttle is open, steam from steam chest $S$ flows beneath

the by-pass valves and holds them up against their seats. When the throttle is closed, the valves drop from their seats by gravity and open communication between the ends of the high-pressure cylinder as follows: From the back end of cylinder *1* through steam port *a*, port *x*, by-pass valves *B* and *B'*, port *y*, and the steam port *b* to the front end of the cylinder.

**6. Starting Valve.**—In order that the locomotive may be worked simple or compound at will, a starting valve *S V*, Fig. 5, is employed. This consists simply of a plug valve (operated from the cab by means of a lever attached to the valve stem *v*) that controls the opening of a passage connecting the two steam passages of the high-pressure cylinder. Although in the same casing as the by-pass valves, the starting valve operates entirely independent of them, and in fact is nothing more than a non-automatic by-pass valve for the high-pressure cylinder.

When it is desired to operate the locomotive simple, the engineer moves the starting valve to the position shown in Fig. 5 (*a*); this opens port *E* and forms communication between port *x* and port *y* through ports *E* and *F*, as indicated by the arrows. To work the engine compound, the valve *S V* is made to cover port *E*, thereby closing communication between ports *x* and *y* through the starting valve. The by-pass valves *B* and *B'* are held closed as long as the throttle is open. The starting valve is open when the starting lever *L* is vertical, as in Fig. 6, and is closed when the lever inclines toward the rear.

**7. Operation of Starting Valve.**—The operation of this valve is best explained by referring to Fig. 6. From the diagram, it will be seen that the starting valve simply acts as a mechanical by-pass valve between the cylinder steam passages *a* and *b*. The diagram shows valve *SV* open and the steam valve *5* in mid-position covering the ports. When the valve *5* is in position to admit steam to the front end of the cylinder through steam passage *b*, the steam flows also through the ports *y*, *F*, *E*, and *x* into steam passage *a*, then divides and passes into the back end of the cylinder

and into the receiver *R*. When steam valve *5* is admitting steam into the back end of the cylinder the action is reversed: Steam then passes from the steam passage *a* through the

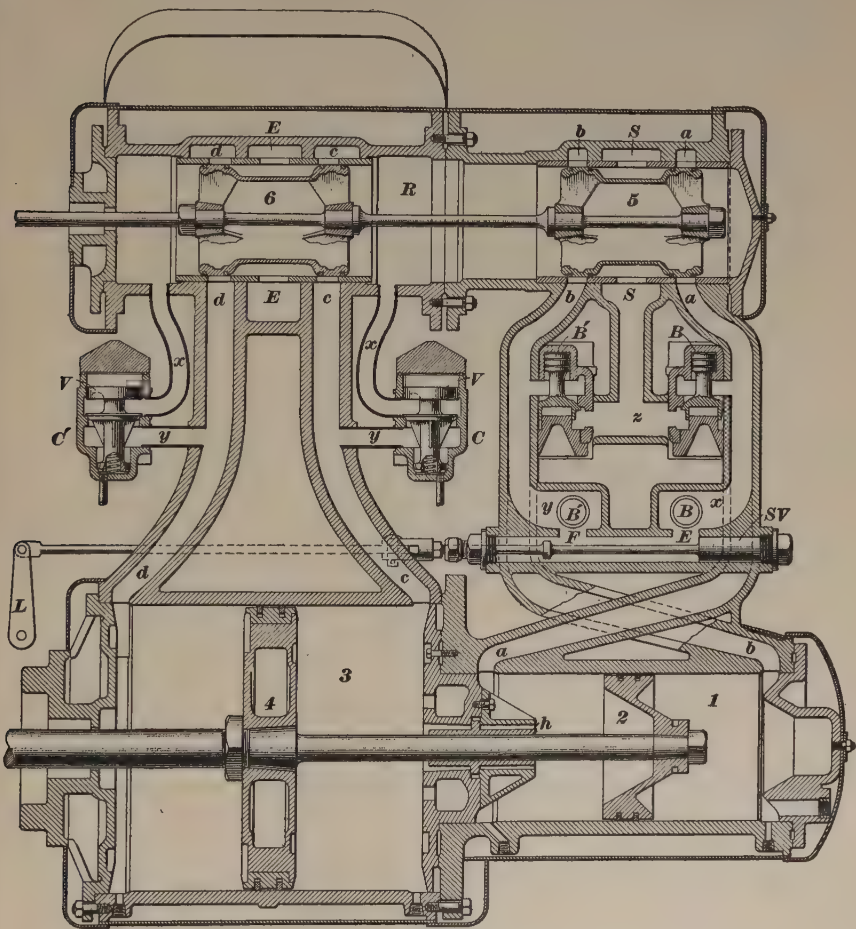



Fig. 6

starting valve into steam passage *b*, where it fills the front end of the cylinder and flows into the reservoir *R*.

It thus will be seen that when the starting valve *SV* is open and the engine working steam, both ends of the

high-pressure cylinder are filled with high-pressure steam. Valve *5* admits steam direct to the steam side of the piston, while the exhaust side of the piston and the receiver *R* are directly connected and filled with steam through the starting valve.

## OPERATION

**8. Working Simple.**—Compound locomotives should never be worked simple except when starting a train or when in danger of stalling on a grade, and then should not be worked simple longer than necessary. They should always be worked simple when starting a train; otherwise, when the high-pressure cylinder exhausts into the receiver and steam is admitted to the large low-pressure piston, the engine will start forwards with a jerk that will cause a disagreeable lurch if not a break-in-two.

To start a locomotive simple, the engineer, by means of a lever in the cab, opens the starting valve. The steam valve *5* then admits live steam from the high-pressure steam chest *S*, Fig. 7, into the steam end of cylinder *1* direct; steam also passes through the starting valve into the exhaust end of the cylinder and into the receiver *R*, whence it is used in the low-pressure cylinder. In this way live steam is worked in the low-pressure cylinders until the engineer converts the engine to compound by closing the starting valve. When working simple, both ends of the high-pressure cylinders are filled with live steam so that the high-pressure piston is practically balanced. The increased power of this engine when working simple is due to using live high-pressure steam in the low-pressure cylinders.

**9. Working Compound.**—When working compound, the low-pressure cylinder is operated by the steam that is exhausted into the receiver *R* from the high-pressure cylinder. Both the starting valve and the by-pass valves are closed.

The operation of the engine for a forward and back stroke of the pistons is indicated in Figs. 8 and 9. Referring to Fig. 8, high-pressure live steam is entering the back end of the high-pressure cylinder while the steam after being

expanded in the high-pressure cylinder is exhausting from the front end of cylinder into the receiver *R*. At the same time, the back end of the low-pressure cylinder is receiving

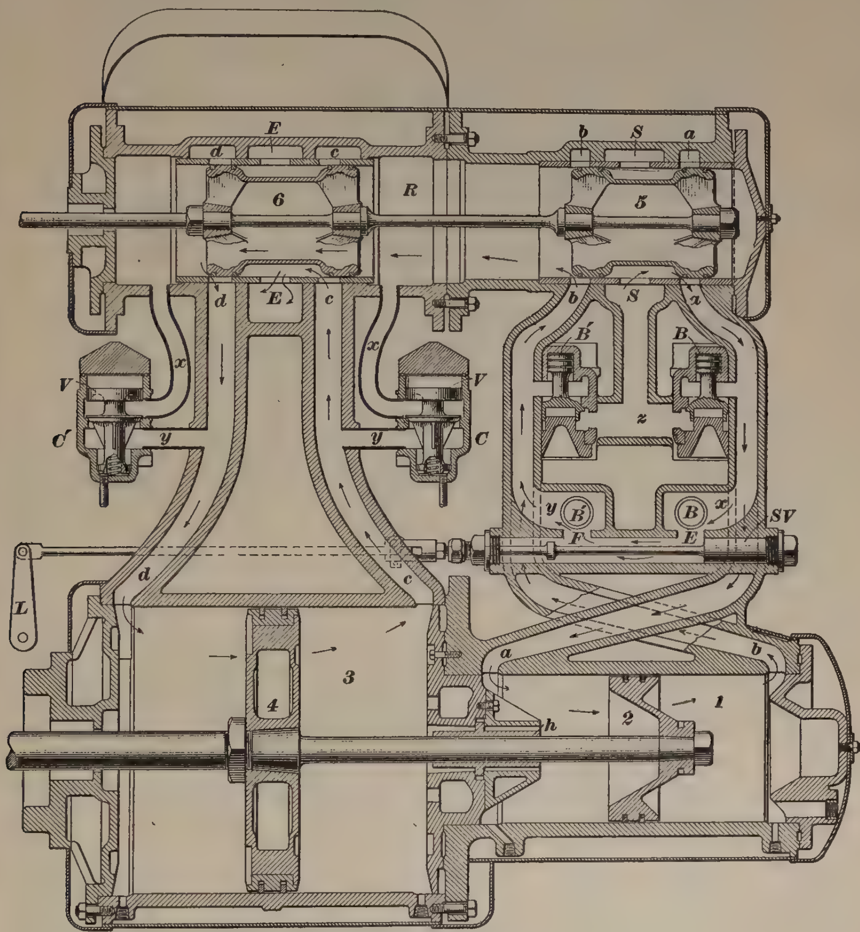



FIG. 7

low-pressure steam from the receiver, and the front end is exhausting into the atmosphere.

The distribution of steam on the back stroke, Fig. 9, is just the reverse of what it is on the forward stroke.

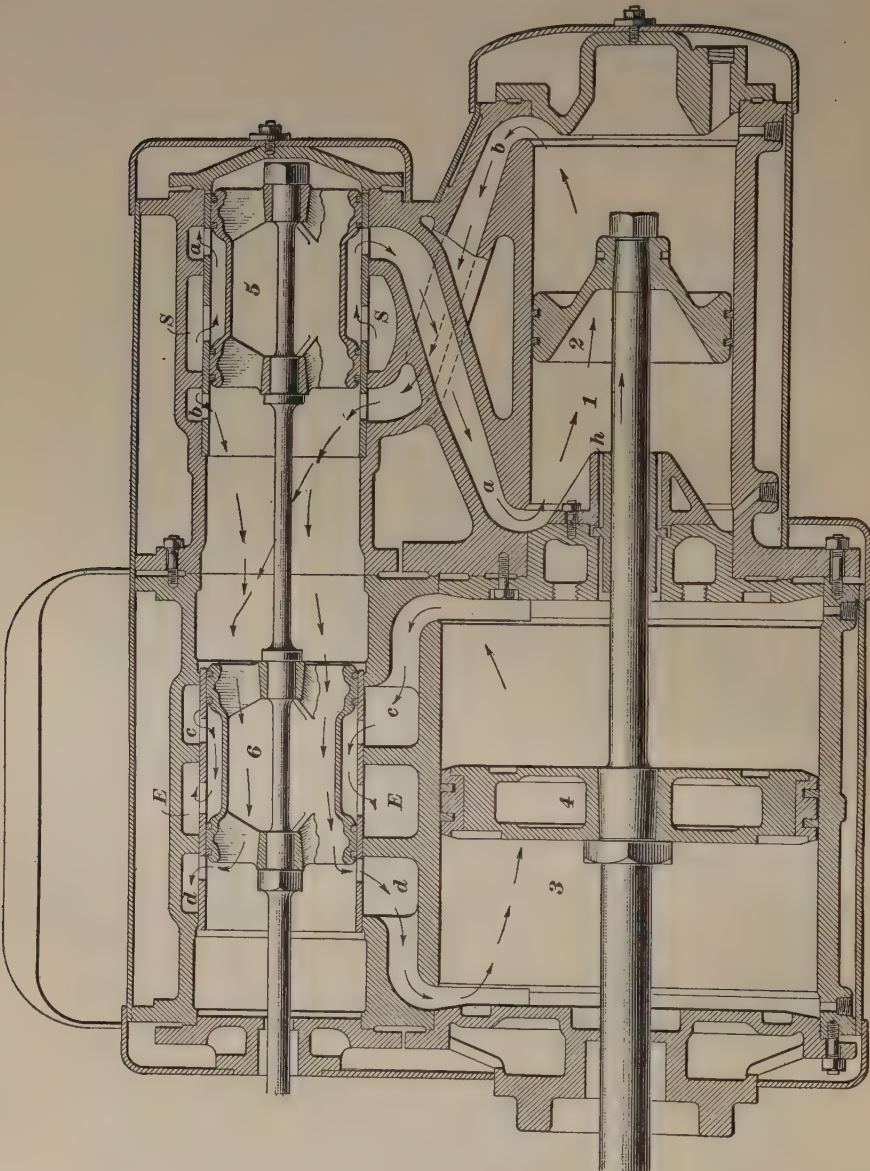



FIG. 8

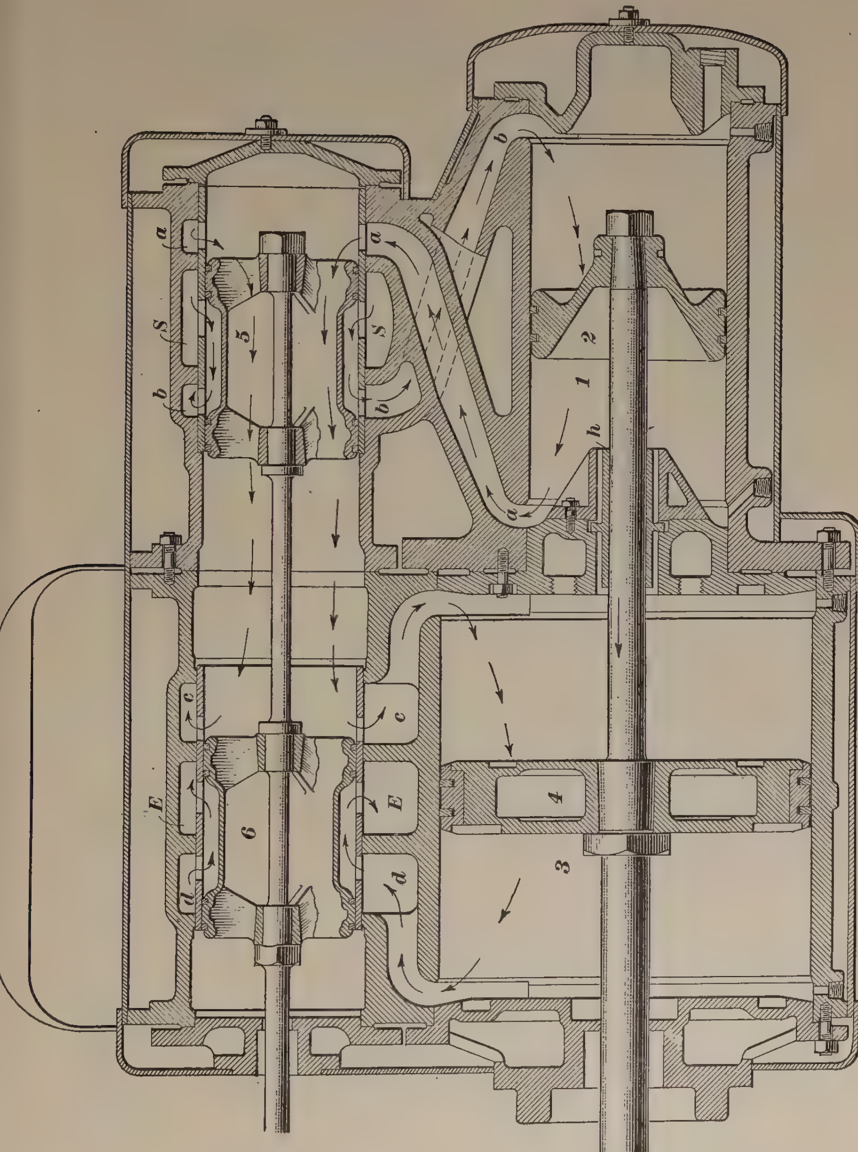



FIG. 9

**10.** The greatest economy will be obtained if dry steam is used; therefore, care should be taken not to carry the water too high in the boiler. Also, in lubricating this engine, the high-pressure cylinder should receive the most oil when working steam, but the low-pressure cylinder should receive the most when drifting.

---

## BREAKDOWNS

**11. General Considerations.**—In the event of a breakdown on the road, the same methods of handling it may be used as with a simple engine, except in the case of trouble in the cylinders.

If necessary to remove the low-pressure piston, take off the high-pressure cylinder front head and the nut on the end of the piston rod; disconnect the main rod, take down the guides, and take off the low-pressure cylinder head; the crosshead, piston, and piston rod can then be removed.

To examine the low-pressure packing rings, proceed as follows: Place the side to be examined on the back center, loosen the back end of the guides and remove the nuts from the cylinder-head bolts; next, shove the guides and cylinder head as far back as they will go. It is then an easy matter to get at the follower bolts so that the rings can be examined or renewed.

In loosening the back end of the guides, take out the four bolts that fasten the guide plate to the main guide yoke; by so doing, the liners of the guides will not be disturbed.

**12. Broken High-Pressure Piston Rod.**—What to do in a case of this kind depends on where the rod breaks, and the damage it does when it lets go. If the rod should break close up to the high-pressure piston, and, by chance, not knock out the high-pressure cylinder head, the engine can be prepared for movement under its own steam by simply taking out the high-pressure piston. This will make the high-pressure cylinder part of the receiver $R$, and the low-pressure cylinder on that side will be working live high-pressure steam direct.

However, if, as is most probable, the cylinder head is knocked out when the piston rod breaks as above, the valve rod on this side must be disconnected and the valves clamped in mid-position so as to cover the steam ports. The main rod can be left up, the low-pressure cylinder being kept well oiled through the indicator plug openings.

If the rod breaks some distance back from the high-pressure piston, the sleeve *h* should be removed (if not already broken out) when the high-pressure piston is taken out.

**13. Broken Low-Pressure Piston Rod.**—If the piston rod breaks back of the low-pressure piston, the chances are that considerable damage will be done, and just what to do under the circumstances will depend on the extent of the damage. In any event, the valve rod must be disconnected and the valves clamped so as to cover the steam ports. Also, the main rod must be taken down and the crosshead and pistons moved as far forwards as possible and securely blocked in that position. The engine is then ready to proceed, working one side only.

**14. Broken Front Cylinder Head.**—In the event of the high-pressure front cylinder head being knocked out without injury to the pistons or rods, remove any broken parts that might cause trouble, disconnect the valve rod on that side, and clamp the valve in mid-position. Remove the indicator plugs from the low-pressure cylinder and the back indicator plug from the high-pressure cylinder on that side so that the cylinders can be kept well oiled through the openings, and proceed with the main rod up.

**15. Broken Valve Stem.**—In the event of a broken valve stem, disconnect the valve rod and clamp or block the valve in mid-travel; remove the indicator plug on the disabled side and proceed with the main rod up. Keep the cylinders well oiled through the indicator-plug openings.

RUNNING TESTS FOR BLOWS

**16. General Considerations.**—That a compound engine is blowing can be told by variations in the intensity of the sound of the exhaust, even though the beats of the exhaust occur at regular intervals. The engineer, therefore, should pay particular attention to the sound of the exhaust with the idea of determining which side of the engine the trouble is on.

Peculiarities of the exhaust can best be distinguished when the engine is running at slow speed. However, when the exhausts from the two sides are of unequal volume, care must be taken not to make the mistake of thinking that two light exhausts on one side indicate two heavy exhausts on the opposite side. Remember that the exhausts from one side are probably normal and that the exhausts from the other side may be either too light or too heavy. Remember, also, that the exhausts from the right side of the engine occur as the right main pin nears the centers, while the exhausts from the left side occur as the right main pin nears the quarters.

**17. Two Heavy Exhausts.**—The sound of the exhaust is regulated by the pressure of the steam in the low-pressure cylinders at the moment exhaust occurs. As the same amount of expansion should take place in both low-pressure cylinders, if steam is admitted into one cylinder at a higher pressure or for a longer time than the other, that cylinder will have a greater pressure at the moment of exhaust; consequently, it will give a heavier exhaust than the other cylinder. The low-pressure cylinders get their steam supply from the receiver so that two heavy exhausts from one side indicate that the pressure in the receiver $R$ is higher than it should be. This can be due: To the packing rings *1* and *2*, or *3* and *4* leaking or being broken, allowing high-pressure steam to blow into the receiver $R$ direct; to the packing ring *2* or *3* being broken, allowing steam to blow into the high-pressure cylinder after cut-off has occurred, thus charging it

with an extra volume of steam that is exhausted into the receiver; to the high-pressure piston packing rings being badly worn or broken; to the starting valve or a high-pressure by-pass valve leaking; or to a cracked bridge or loose bushing of the high-pressure valve. As these defects cause a blow to the receiver, they are not indicated like a blow to the atmosphere; therefore, in the event of two heavy exhausts occurring on one side of the engine, test that side for the above defects.

**18. Two light exhausts** from one side indicate that the receiver pressure is less than it should be or that the low-pressure piston packing rings are badly worn. The reduced receiver pressure may be due: To the valve packing ring *5*, *6*, *7*, or *8* being broken or leaking badly, allowing receiver steam to escape direct to the exhaust, or to the low-pressure piston packing rings being broken or badly worn, either of which will cause a blow to the exhaust; or, to a loose valve bushing, or a cracked bridge of the low-pressure valve, either of which will cause a blow on one stroke only.

**19. One heavy exhaust** on a side, provided the exhausts occur at the proper intervals, indicates that one end of the low-pressure cylinder on that side is receiving either a higher pressure or a greater volume of steam than it should. This may be due: To the ring *5* or *8* being broken, in which case there would also be a direct blow after the heavy exhaust, which would continue until the exhaust port closed at compression; to a broken low-pressure by-pass valve, which will allow steam to enter its end of the low-pressure cylinder after cut-off has occurred; or to the sleeve *h* leaking, allowing high-pressure steam to enter the front end of the low-pressure cylinder.

If one heavy and one light exhaust occur on a side *and the intervals between the exhausts are unequal*, the trouble is caused by a derangement in the valve motion and is not due to a blow.

STANDING TEST FOR BLOWS

**20. High-Pressure Valve.**—To test for a blow in a high-pressure valve on either side, place that side of the engine on the top quarter with the reverse lever in the center notch. In this position the pistons will be in about the center of the cylinders and the valves will be in mid-position covering the steam ports. Next block the drivers or set the brake, see that the starting valve is closed, remove the indicator plugs or open the cylinder cocks on that side, and then open the throttle. If steam blows from one of the indicator plugs (or cylinder cocks), either the steam valve or a by-pass valve is blowing. Inspect the by-pass valve on the *opposite* end (on account of ports $a$ and $b$ crossing) from the cylinder cock through which steam is flowing; if these are tight the trouble is in the steam valve. If necessary, chalk the by-pass valve and try it on its seat to see if it has a bearing at all points.

**21. Low-Pressure Valve.**—To test this valve, place the engine on the top quarter on the side to be tested, with reverse lever in the center notch and the starting valve closed. Remove the back high-pressure by-pass valve $B'$ from its case and replace the valve cap, block the drivers or apply the brake, and then open the throttle. Remove the back indicator plug of the high-pressure cylinder or block open the back cylinder cock to prevent pressure accumulating in the back end of the high-pressure cylinder in the event of the starting valve, main valve, or packing rings leaking. This prevents the possibility of a blow occurring through the sleeve $h$ to complicate matters.

Next move the reverse lever forwards of the center notch just enough to crack the steam passage $b$ to the receiver, Fig. 6, without uncovering the back low-pressure steam port $d$, and allow high-pressure steam to flow from steam chest $S$, through by-pass $B'$ and passage $b$, into the receiver $R$. Now remove the indicator plugs of the low-pressure cylinder, if there are any, or open the low-pressure cylinder cocks; if

steam escapes from the rear cock either the steam valve *6* or the rear by-pass valve $C'$ is leaking. An inspection of the by-pass valve will determine which. If steam escapes from the front cock, it indicates either a leaky steam valve *6*, or front by-pass valve $C$; if inspection shows that the by-pass valves are all right, the trouble is in the valve. Replace the by-pass valve $B'$ when through with the test.

**22. Piston-Rod Packing Sleeve.**—A method of testing this sleeve is to place the engine on the top quarter with reverse lever in forward motion and starting valve closed. Then block the drivers or set the brake, open the throttle and the back end of the high-pressure cylinder will be filled with high-pressure steam. There will be no steam in the receiver, so that if the front low-pressure indicator plug is removed or the corresponding cylinder cock opened and there is a blow from it, the trouble is due to a leaky sleeve $h$.

**23. High-Pressure Piston Packing.**—To test these packing rings, place the engine on the top quarter with the lever in back motion, the drivers blocked, the starting valve closed, and the throttle open. This connects steam passage $b$, Fig. 5, with the steam chest $S$ and fills the front end of the cylinder with live steam. Next remove the back indicator plug or open the back cylinder cock of the high-pressure cylinder; if steam blows from it, either the piston packing is blowing or there is a leaky by-pass valve $B$ or starting valve. Move the reverse lever into the forward motion; replace the back indicator plug and remove the front one; if the blow stops it indicates a leaky by-pass valve. A piston-packing blow, however, will be much harder than either of the others, unless the by-pass valve is unseated, which causes the hardest blow of all. Examine by-pass valve $B$; if this is found steam-tight, and the blow is a hard one, it can safely be considered a piston-packing blow.

**24. Low-Pressure Piston Packing.**—To test this packing for a blow, place that side of the engine on the top quarter with reverse lever in back motion, starting valve open, drivers blocked, and the throttle open; this admits

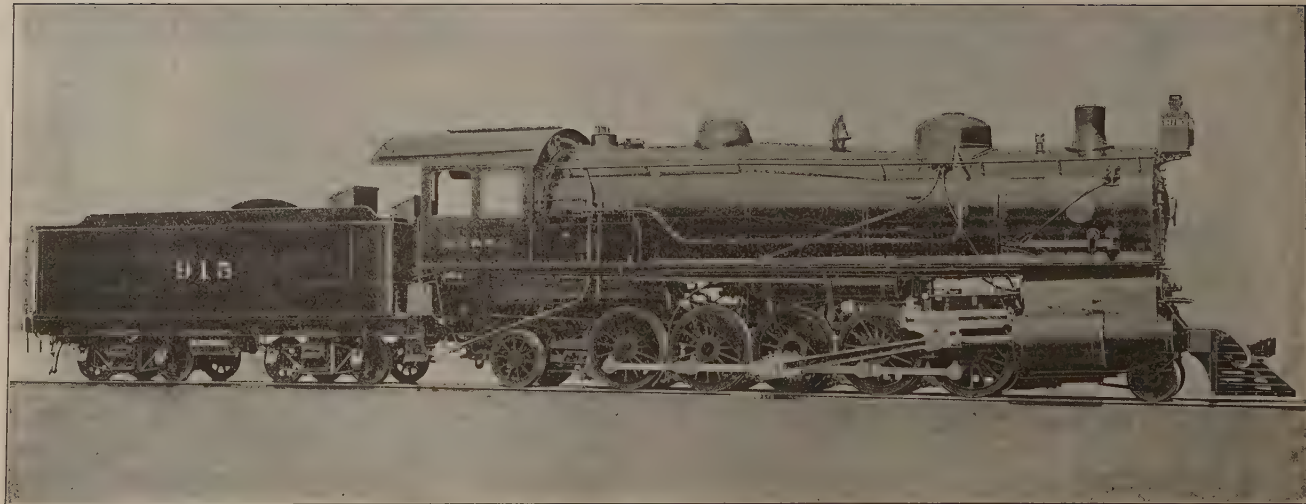


Fig. 10

high-pressure steam into the front end of the high-pressure cylinder. Also, steam flows through the starting valve into the back end of the high-pressure cylinder and into the receiver *R*, whence it flows into the front end of the low-pressure cylinder. Remove the back indicator plug or the back low-pressure cylinder cock; if steam flows from this either the piston packing or the back by-pass valve is blowing. Move the reverse lever to the forward motion and change indicator plugs; if the blow stops, it indicates a leak past the by-pass valve; or, an examination of the by-pass valve will show whether or not it is leaking. If a low-pressure by-pass valve is unseated, the fact will be indicated at once both by a violent blow and by steam discharging from the drip pipe *d* of the by-pass valve that is unseated.

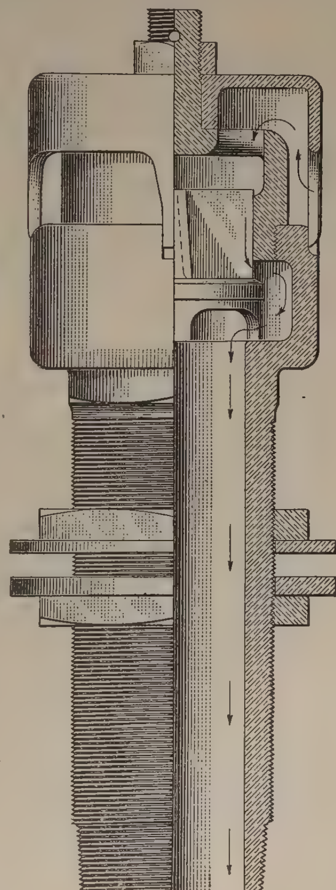
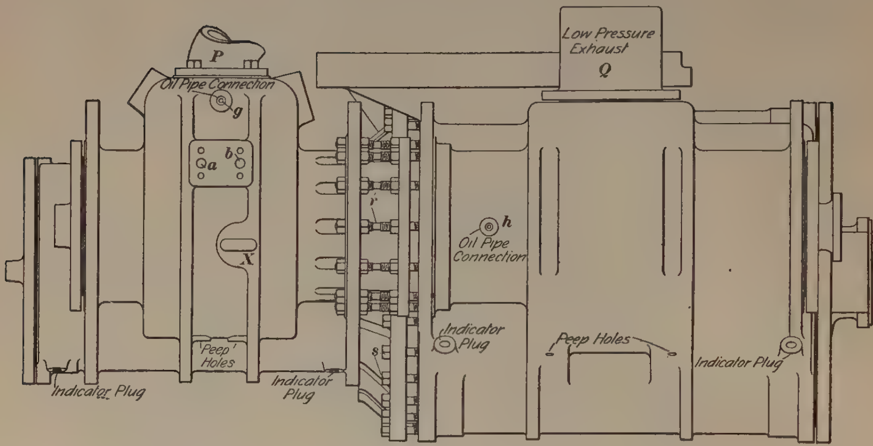


FIG. 11

## BALDWIN TANDEM COMPOUND

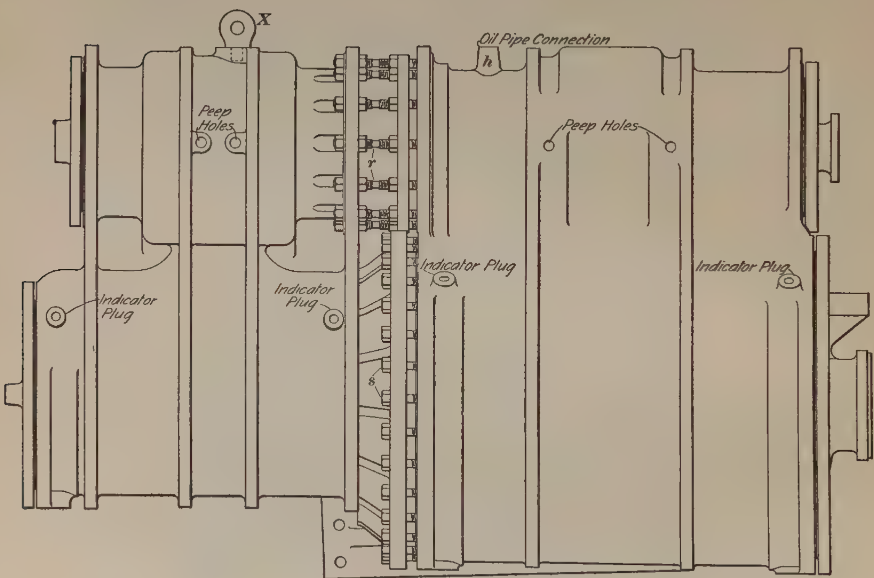
### DESCRIPTION

**25. General Arrangement.**—A tandem compound built by the Baldwin Locomotive Works is shown in Fig. 10, from which a good idea of the arrangement of the cylinders, etc. can be had. This engine is not fitted with automatic by-pass valves, but has a starting valve that acts as a by-pass when open; it also has relief valves in the cylinders and a large one in the dry pipe; the latter,



P
Oil Pipe Connection
g
a
b
X
Peep Holes
Indicator Plug
Indicator Plug
r
s
Low Pressure Exhaust
Q
h
Oil Pipe Connection
Indicator Plug
Peep Holes
Indicator Plug

(a)



X
Oil Pipe Connection
h
Peep Holes
Peep Holes
r
Indicator Plug
Indicator Plug
Indicator Plug
Indicator Plug
s

(b)

Fig. 12

extending through the smokebox about midway between the stack and the sandbox, as shown in Fig. 10. This relief valve, Fig. 11, admits air into the dry pipe, thence through the steam pipes into the steam chests when the engine is drifting.

A small crane is placed on each side of the engine, above the running board, a little forwards of the stack, for use in removing the high-pressure cylinders.

In this engine, the cylinder saddle is cast separately from the cylinders; each cylinder with its valve chest is cast in one piece, but the cylinders themselves are cast separately. The method of connecting the cylinders together is shown in Fig. 12. The intermediate cylinder head is made in two parts, *A*, *B*, Fig. 13, so as to provide for a special form of metallic rod packing that goes in the space *C*. The parts *A* and *B* are turned up to the same dimensions as the counterbore of the low- and high-pressure

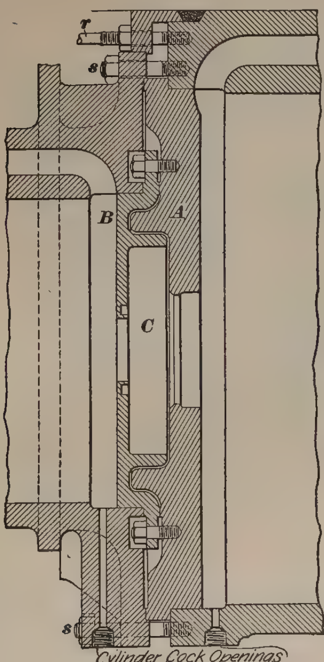



Fig. 13

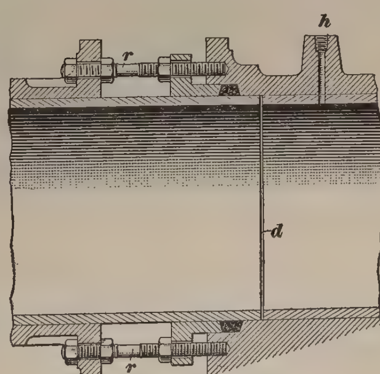



Fig. 14

cylinders, respectively, and the head is entered in each casting as shown to hold the cylinders in correct alinement. This head is not bolted to either cylinder; it is held in position between the flanges of the two cylinders by the bolts *s*, *s* that

secure the cylinder flanges together, but the bolts do not pass through the intermediate head. Removing bolts *s*, *s* disconnects the cylinders from each other and also frees the intermediate head. In order to facilitate the making of a steam-tight joint between the high-pressure cylinder and valve chest and the low-pressure cylinder and valve chest, the connection between the two valve chests is made through the stuffingbox, Fig. 14. This permits of a perfect joint being made

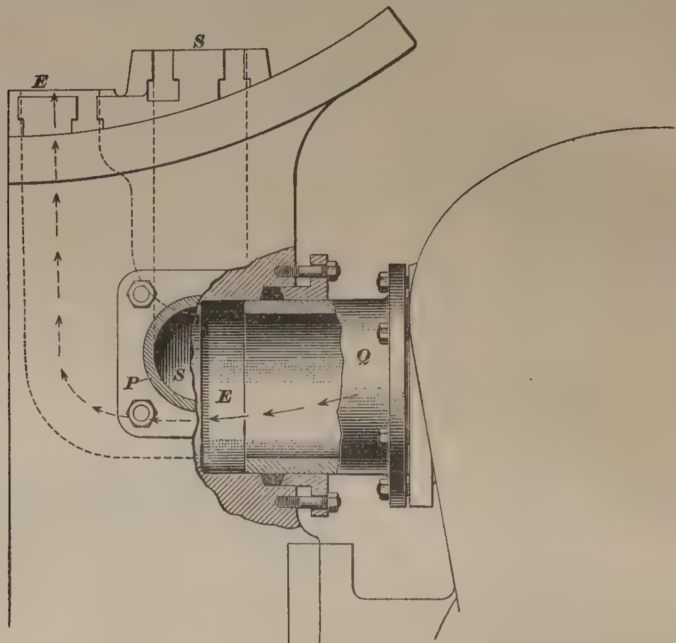



FIG. 15

between the cylinders without interference from the valve chest joint, the stuffingbox being depended on to make a steam-tight joint between the valve chests. The studs *r*, *r* that bind the two valve chests together also serve to hold the stuffingbox in place. The valve-chest bushing is in two pieces, being divided at *d*, so that the high-pressure cylinder and its valve chest may be readily separated from the low-pressure cylinder.

Connection between the cylinder saddle and the exhaust passage from the low-pressure valve chest is made through a stuffingbox, Fig. 15, in order to give a certain amount of flexibility while at the same time maintaining a steam-tight joint.

The live-steam connection between the cylinder saddle and high-pressure valve chest is made by the pipe *P*, Figs. 16 and 17.

**26. Steam Passages in Cylinder Saddle.**—Fig. 16 is a front view and Fig. 17 a side view of a portion of the left half of the cylinder saddle. Fig. 16 is sectioned on the line

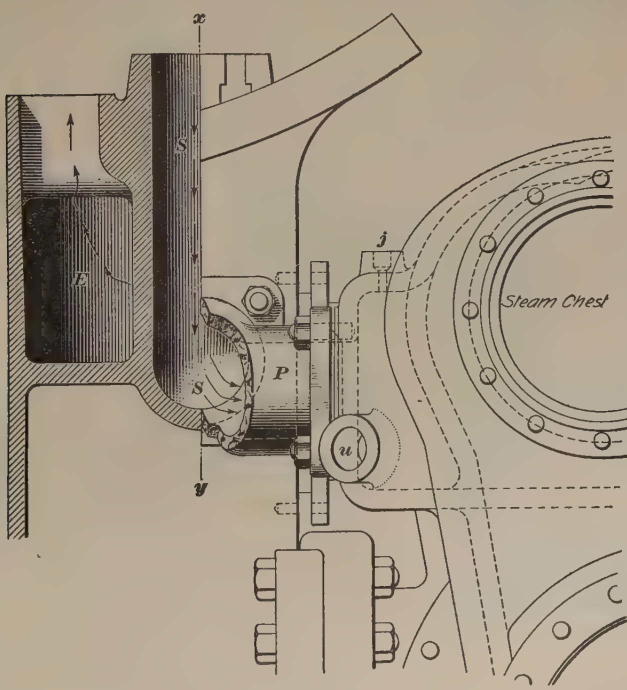
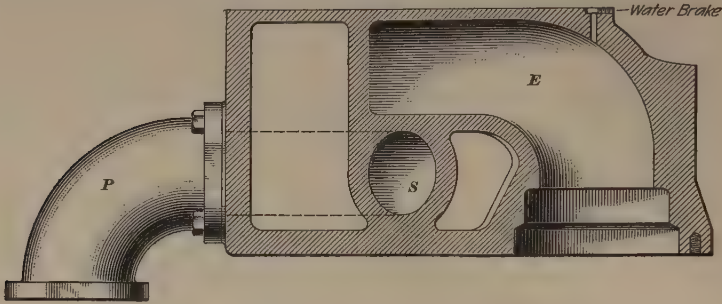



Fig. 16

$xy$ back as far as the line $uv$, Fig. 17, while Fig. 17 is cut away to show the exhaust passage *E* and the steam passage *S*. The exhaust passage, as usual, is back of the steam passage;

but in this engine it extends backwards and connects with the low-pressure valve chest through the connection $Q$, Fig. 15.



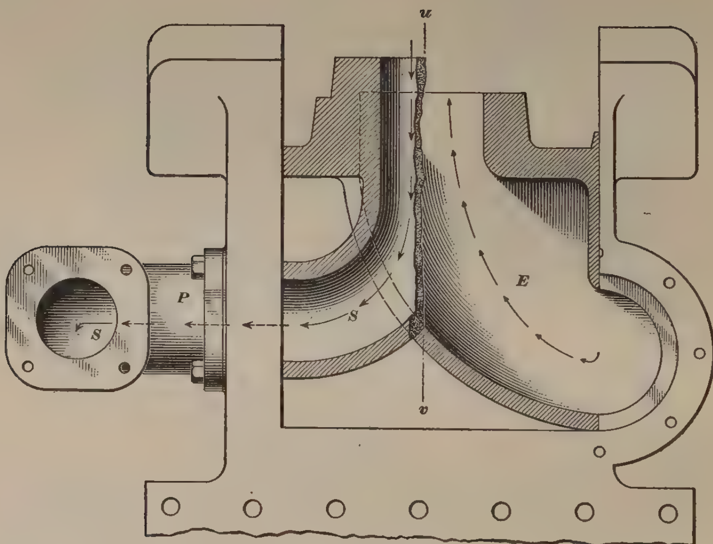




FIG. 17

The steam passage extend forwards and connects with the steam pipe $P$, as shown in Fig. 17.

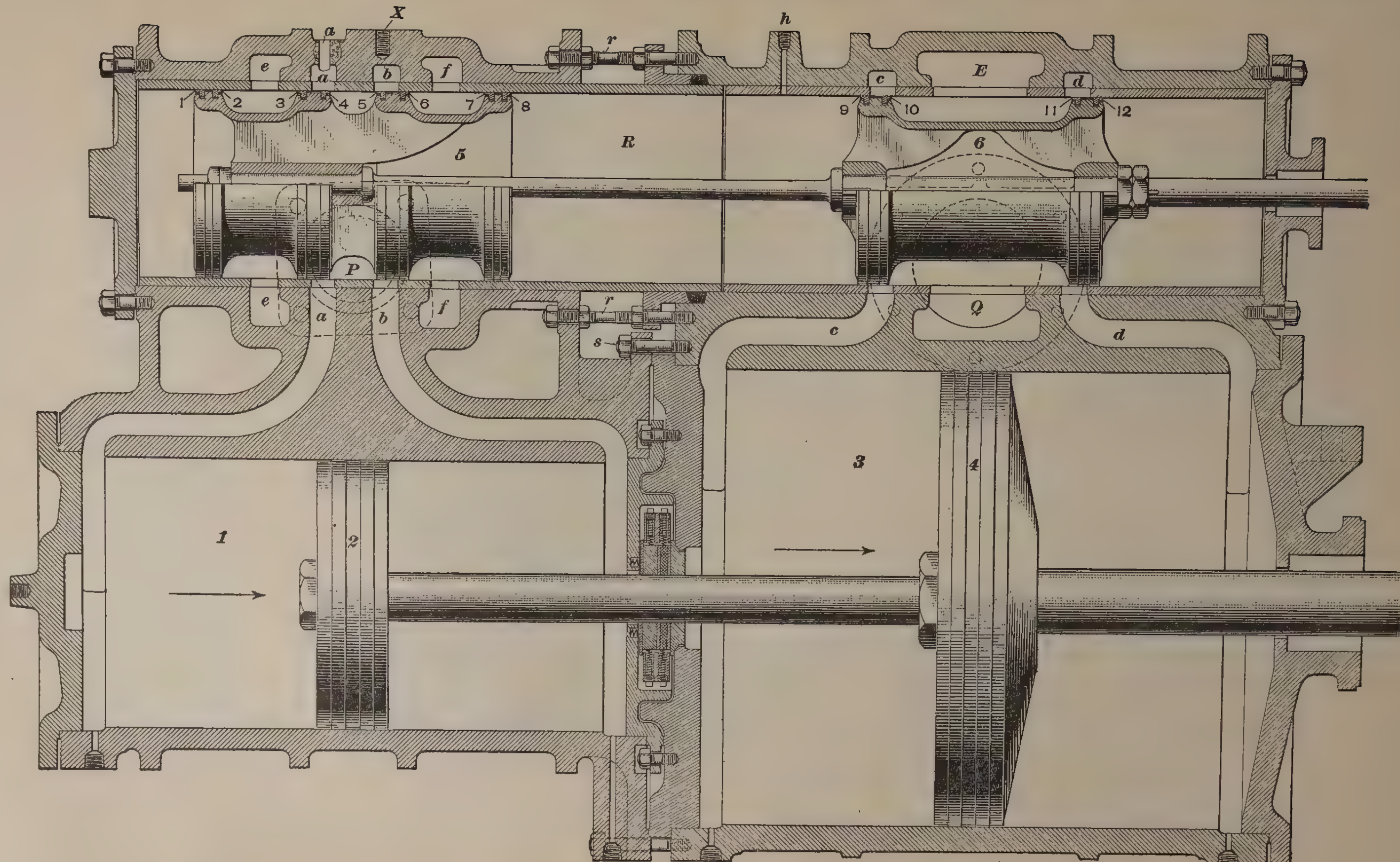



FIG. 18

ARRANGEMENT OF VALVES AND PASSAGES

**27.** A sectional view of the left-side cylinders and valves is given in Fig. 18, in which *1* and *2* are respectively the high-pressure cylinder and piston; *3* and *4*, the low-pressure cylinder and piston; and *5* and *6*, the high-pressure and low-pressure valves. Steam is conducted to the high-pressure valve chest through the steam pipe *P* (indicated by the dotted circles), which divides into branches that connects with the steam passages *e f* surrounding the valve bushing. These passages, therefore, are the valve-chest inlets for the high-pressure steam. The final exhaust occurs through the exhaust outlet *Q* (indicated by dotted circles in the low-pressure valve chest), which connects directly with the exhaust passage *E* surrounding the valve bushing.

**28. The Piston Valves.**—The valves used with this engine are piston valves of the hollow or balanced type. The high-pressure valve *5* is really equivalent to two internal admission valves *G*, *H* separated by a space *K* of 3 inches, as shown in Fig. 19.

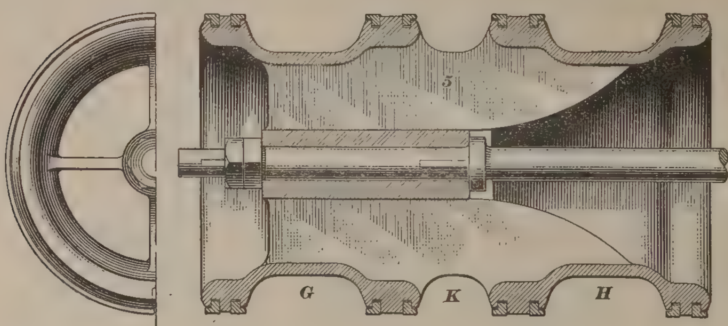



FIG. 19

The cavity *G* is the admission cavity for the steam passage *a*, Fig. 18, while *H* is the admission cavity for the steam passage *b*. Neither cavity has anything to do with exhausting the steam from the cylinder; that is accomplished by moving the valve so that the space *K* is directly above

the steam passage of the end of the cylinder to be exhausted. In this position, the steam passes through *K* into the hollow of the valve and thence to the valve chamber *R*, Fig. 18, which acts as a receiver for the low-pressure cylinder. It will be observed that there is no exhaust cavity in the valve seat of the high-pressure valve. The low-pressure valve *6* is an external-admission balanced piston valve.

**29. Intermediate Head Metallic Rod Packing.** The pistons are on the same piston rod, which passes through the intermediate cylinder head. The metallic packing used to make a steam-tight joint between the two cylinders is shown in Fig. 20. It is contained in the space *C*, Fig. 13, between the parts *A* and *B* of the head.

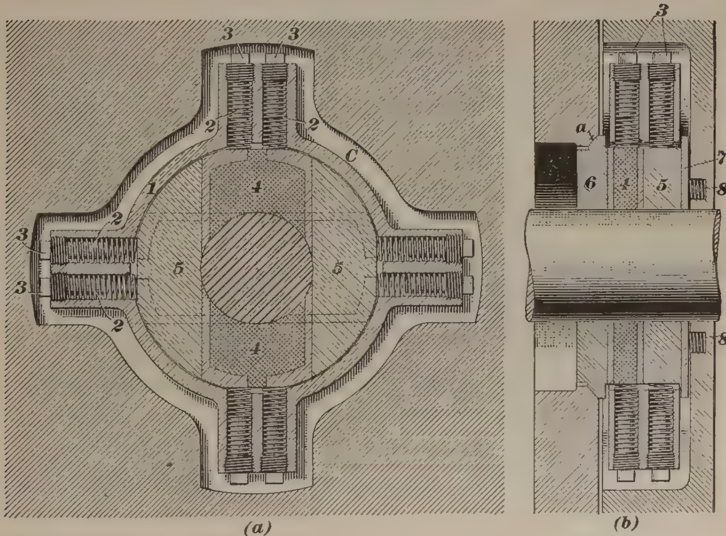



FIG. 20

The packing box *1* consists of a brass ring or casing, with four spring boxes that contain adjusting springs *2* and adjusting screws *3*. The working block *4* of the packing consists of a brass shell filled with Babbitt metal. On either side of the working block, there is a brass block *5* that fills up the remaining space in the packing box.

There are two sets of working blocks used, the second set being placed back of, and at right angles to, the first (as indicated by the dotted lines), in order to break joints and insure a steam-tight packing.

The ring *6* is toward the low-pressure cylinder and makes a steam-tight joint at *a*. The packing is held against the ring *6* by the pressure of the steam in the high-pressure cylinder; but when steam is shut off it is held in place by the follower springs *8* acting against the follower plate *7*.

The packing box *1* is entirely loose in the space *C* of the cylinder head. This allows it to move sufficiently, without breaking the joint, to accommodate any variation in the position of the piston rod.

**30. The Starting Valve.**—The starting valve used with this engine is shown in Fig. 21, in which (*a*) is a side view and (*b*) a sectional view with the top cut away so as to show the valve. The starting valve is bolted to the high-pressure valve chest [as indicated in Fig. 12 (*a*)] with the ports *m* and *n* of the valve registering with the ports *a* and *b* of the valve chest. By referring to Fig. 22, it will be seen that port *m* of the valve connects with a passage leading into the steam passage *a* to the front end of the high-pressure cylinder, while port *n* leads into steam passage *b*. Therefore, when the starting valve is open (handle in the forward position as shown) it forms a direct communication between the two steam passages of the high-pressure cylinder.

The operation of the starting valve is as follows: When the handle is in the forward position, the valve is open; and when in the backward position, it is closed. With the starting valve open and the high-pressure steam valve in position to admit steam to the front steam passage *a* (as in Fig. 22), steam passes through the starting valve, as indicated by the arrows, into the receiver, and thence by the low-pressure valve into the front end of the low-pressure cylinder. When the steam valve is in position to admit steam into port *b*, Fig. 23, the space *K* of the valve registers with port *a* so

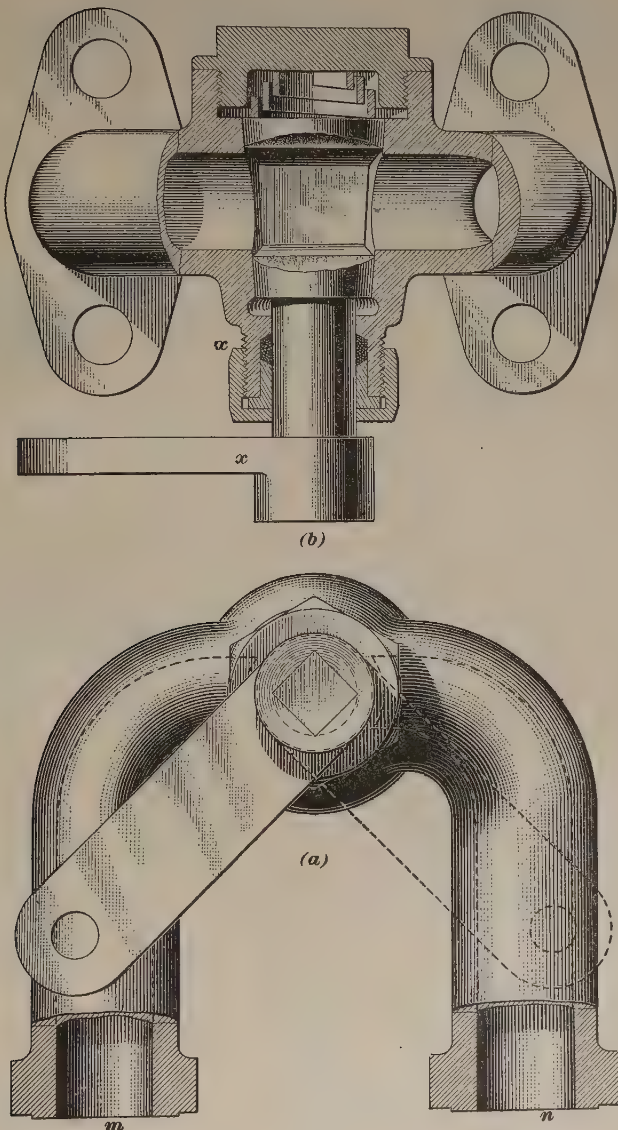



FIG. 21

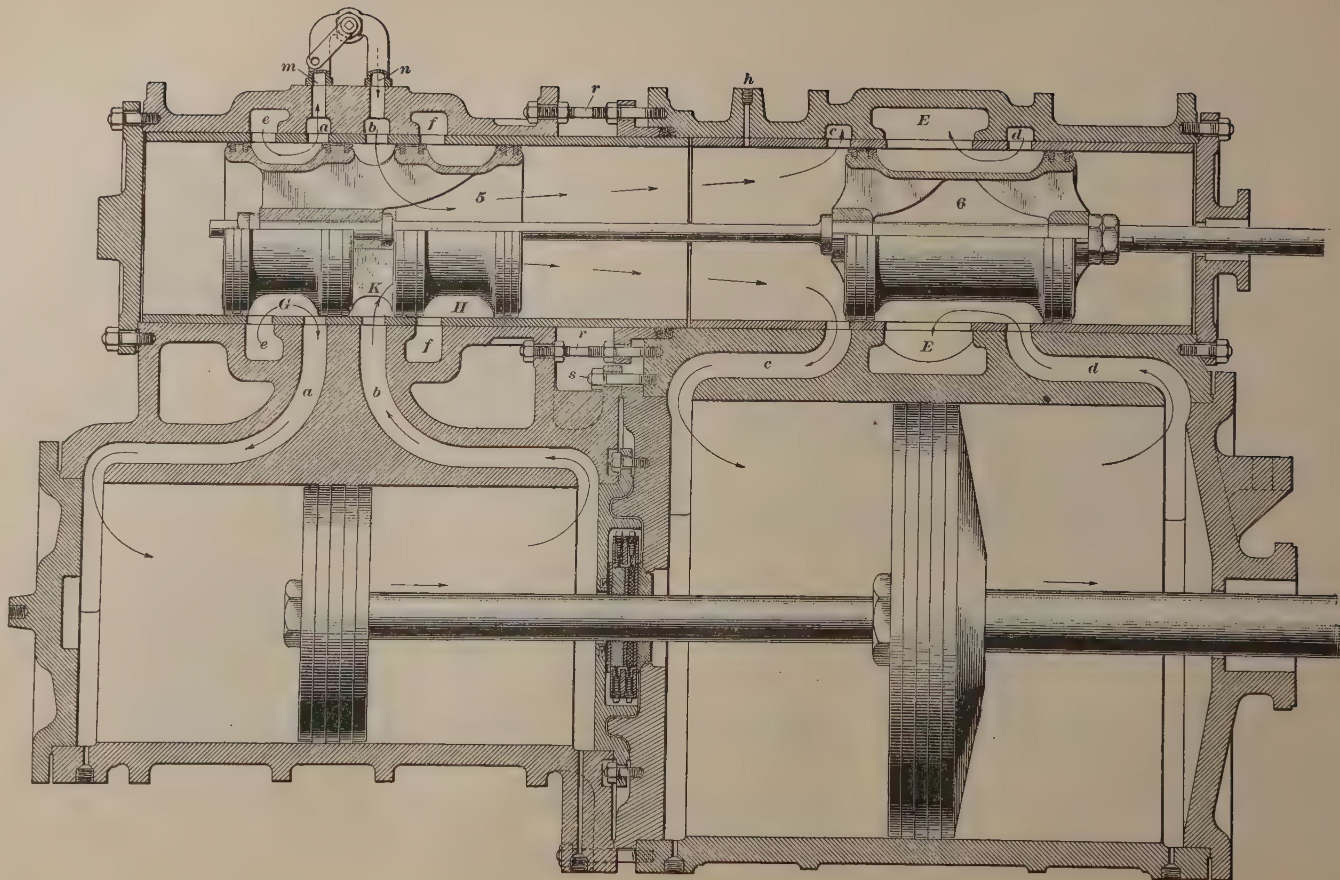



FIG. 22

that the steam from the starting valve can pass again into the receiver and thence into the back end of the low-pressure cylinder.

---

### OPERATION

**31. Working Simple.**—The operation of this engine, when working simple, is as follows: The starting valve is open so that steam is admitted through it into the receiver whence it passes into the low-pressure cylinder, as indicated by the arrows in Fig. 22. Also, high-pressure steam is admitted into the high-pressure cylinder direct, which exhausts into the receiver at all times, as it has no separate exhaust. Live steam is worked in both cylinders when starting the engine.

**32. Working Compound.**—When the engine is working compound, the starting valve is closed and the low-pressure piston is operated by the steam that is exhausted into the receiver from the high-pressure cylinder.

The operation of the engine for a forward and back stroke of the piston is indicated in Figs. 23 and 24. On the forward stroke, Fig. 23, steam from chamber *f* flows through the cavity of the valve, as shown, into the steam passage *b* and the back end of the high-pressure cylinder, forcing the piston forwards. The front end of this cylinder is exhausting into the receiver. At the same time, low-pressure steam from the receiver is admitted into the back end of the low-pressure cylinder, forcing that piston forwards, while the steam in the front end is exhausting to the atmosphere through the exhaust port *E*. The distribution of steam for the backward stroke of the pistons is shown in Fig. 24.

---

### OPERATING

**33. Handling the Tandem.**—In starting a train, first place the reverse lever in the corner, open the cylinder cocks and starting valve, and then gradually open the throttle. Close the starting valve so as to compound the engine as soon as the train is fairly started. As the speed of the train

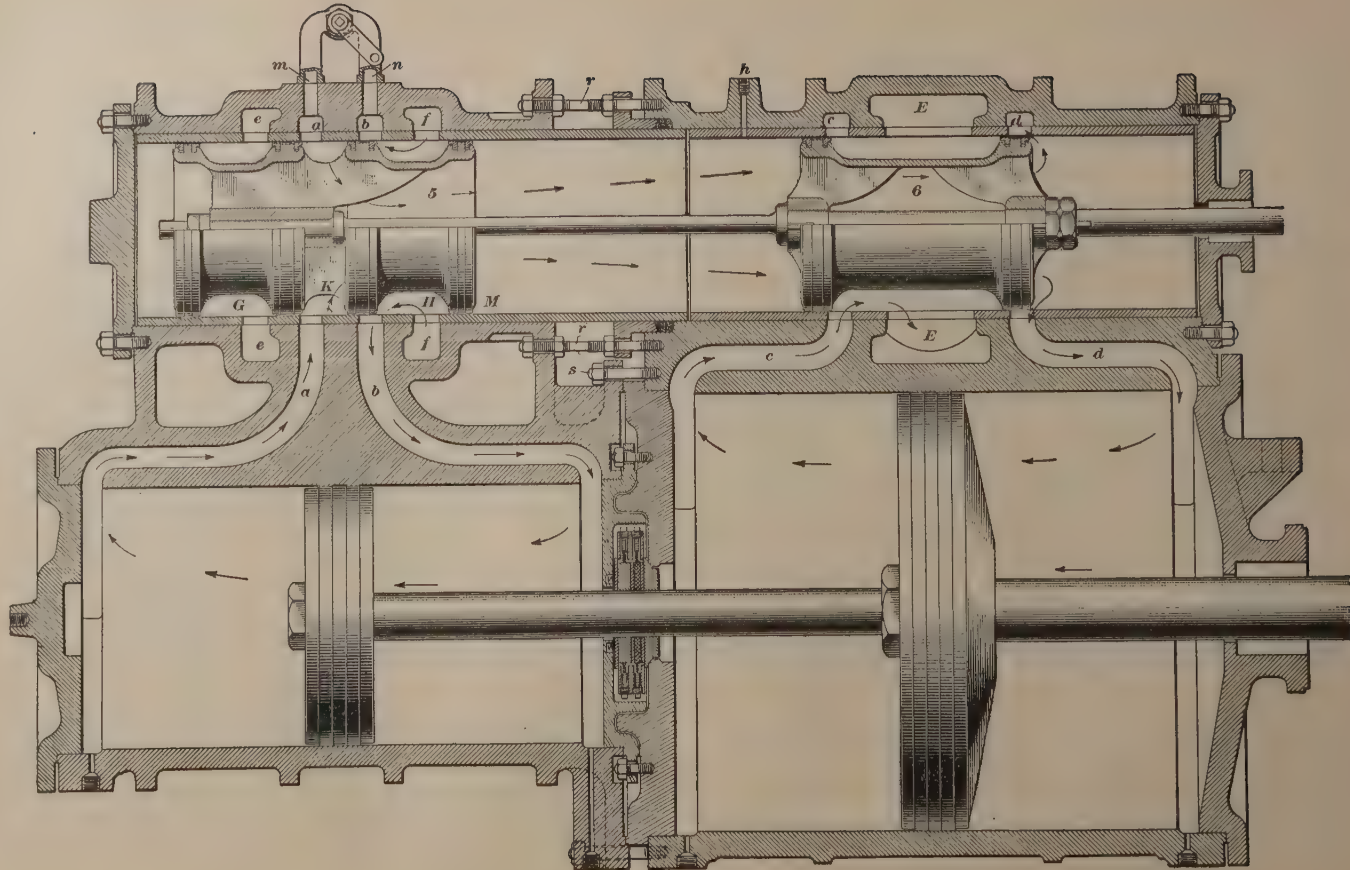



FIG. 23

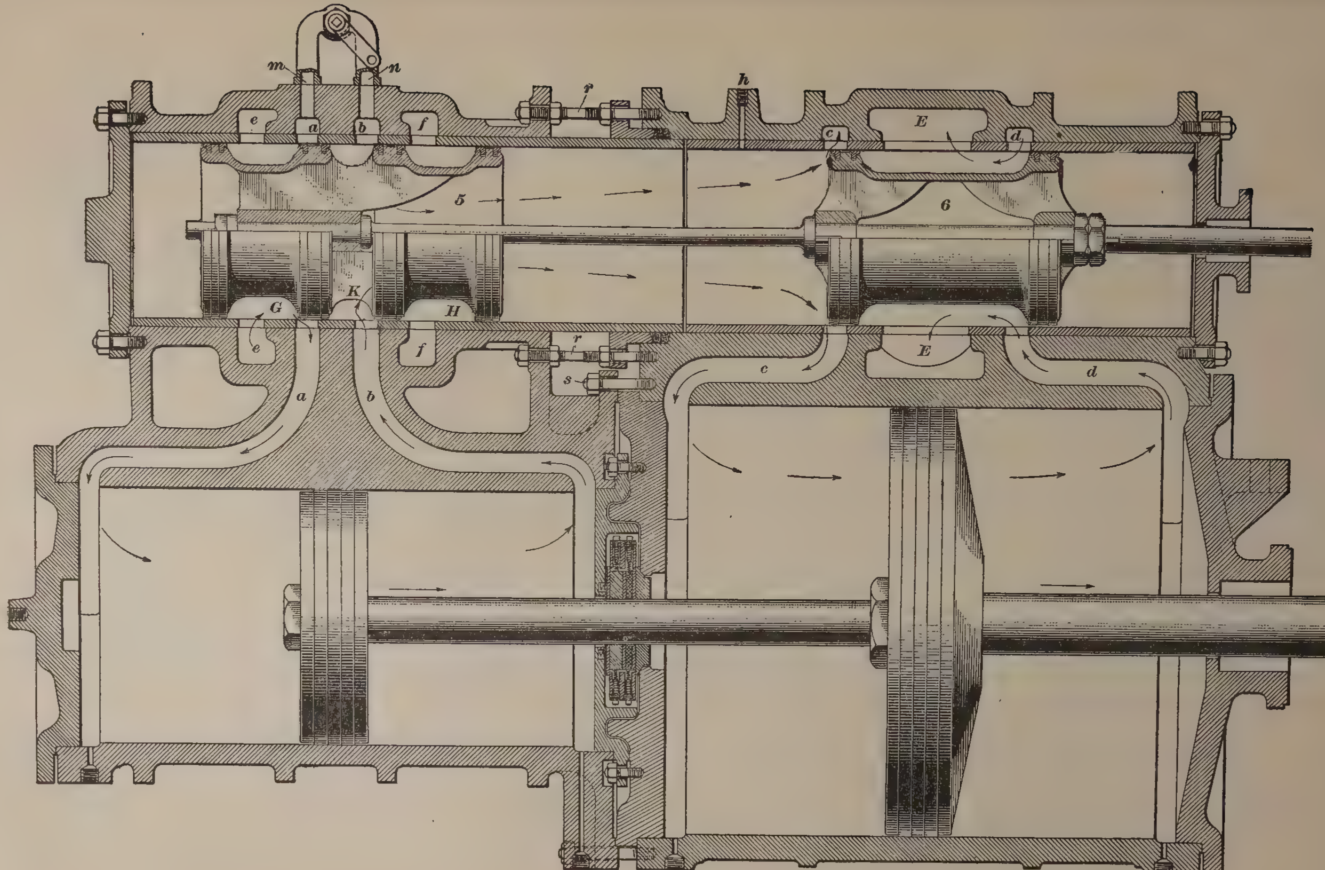



FIG. 24

increases, hook up the reverse lever a notch or two at a time until it is in the proper notch for the speed to be maintained.

On an up-grade, whenever the engine shows signs of slowing down, drop the reverse lever a notch or two at a time soon enough to maintain the speed as nearly as possible. If, after the reverse lever has been dropped to the corner notch, the speed continues to slow down until there is danger of stalling, open the starting valve until the danger is past and then close it.

In drifting down-grade, the starting valve should be open; also, if the grade will permit, open the throttle, just sufficiently to keep the relief valves closed. The steam thus admitted into the cylinders will prevent the formation of a vacuum and will assist in lubricating the cylinders and keep them cool. The reverse lever should be carried as near the corner as practicable.

It is essential that the steam used be as dry as possible; hence, the water in the boiler should not be carried any higher than is necessary for safety. Also, when working steam, the high-pressure cylinder should receive the most oil, but when drifting the low-pressure cylinder should receive the most.

---

### BREAKDOWNS

**34. General Considerations.**—With this engine, the same methods of handling breakdowns may be used as with a simple engine, except in cases of trouble in the cylinders. If necessary to remove the low-pressure piston, the high-pressure cylinder is first taken down and the piston is taken out through the front of the cylinder without touching the back cylinder head or the guides or interfering with the steam valves.

To take down the high-pressure cylinder, screw the threaded eyebolt of the small crane into the tapped hole $X$, as in Fig. 12, in the valve-chest casting so that the cylinder can be properly balanced and handled by the crane. Then remove the cylinder bolts $s$, $s$, Fig. 13, and take the nuts off the valve-chest studs $r$, $r$, Fig. 14, and the cylinder can then be

swung ahead on the crane and removed. The front head of the low-pressure cylinder, not being bolted, can then be easily taken down so that access may be had to the low-pressure cylinder.

**35. Broken High-Pressure Piston Rod.**—If this rod should break close up to the high-pressure piston and the cylinder head not be knocked out, remove the piston and proceed after replacing the cylinder head. If, as is most probable, the cylinder head is broken out, disconnect the valve rod on that side and clamp the valves in mid-position so as to cover the steam ports. The main rod can be left up, but the cylinder should be kept well oiled through the indicator plug openings.

**36. Broken Low-Pressure Piston Rod.**—In the event of this rod's breaking, disconnect the valve rod and clamp the valves in mid-position to cover the steam ports. Disconnect the main rod on that side, and block the crosshead securely as far forwards as possible. The engine is then ready to proceed on one side.

**37. Broken Front Cylinder Head.**—If the pistons or rods are not injured when the cylinder head is knocked out, remove any broken parts that might cause trouble, disconnect the valve rod on that side, and clamp the valves in midposition. The main rod can be left up. Remove the indicator plugs and keep the cylinders well oiled through the indicator openings.

**38. Broken Valve Stem.**—In the event of the valve stem's breaking, remove the broken parts and clamp the valves in mid-travel. Remove the indicator plugs on the disabled side so that the cylinders can be kept well oiled through the openings, and proceed with the main rod up.

---

## RUNNING TESTS FOR BLOWS

**39.** The tests for blows should be made with the engine running at slow speed. Care should be taken to distinguish the sounds of the exhausts from both sides of the engine,

and two light exhausts on one side or two heavy exhausts on the other must not be mistaken for the normal exhausts. To distinguish between the exhausts of both sides of the engine, remember that the exhausts from the side you are looking at occur after the main pin is past the quarters, while the exhausts from the opposite side occur after the main pin is past the centers.

**40. Two Heavy Exhausts.**—Two heavy exhausts from either side indicate that there is a higher pressure in the receiver on the side from which the heavy exhaust occurs than there should be. This may be due: To the packing rings *1* and *2* or *7* and *8*, Fig. 18, leaking or being broken, allowing high-pressure steam to blow into the receiver direct; to the ring *3* or *6* being broken, allowing steam to blow into the high-pressure cylinder after cut-off has occurred, thus charging it with an extra volume of steam that is exhausted into the receiver and raises the pressure above what it should be; to the high-pressure piston packing rings being badly worn or broken, allowing high-pressure steam to escape by them into the receiver; or to a cracked bridge or loose valve bushing of the high-pressure valve. In the event, therefore, of two heavy exhausts occurring on either side of the engine, test that side to see which of the above defects is causing the trouble.

**41. Two Light Exhausts.**—Two light exhausts from either side of the engine indicate too little pressure in the receiver on that side. This may be due: To the rings *9* and *10* or *11* and *12*, Fig. 18, being broken or leaking badly, allowing receiver steam to escape direct to the exhaust; to the low-pressure piston packing being worn or broken, allowing steam taken from the receiver to escape directly to the exhaust; or to a loose valve bushing or cracked bridge of the low-pressure valve.

**42. One Heavy Exhaust.**—If one heavy exhaust occurs on a side, but the other exhausts are at proper intervals apart, it indicates that one end of the low-pressure cylinder on that side is receiving a larger volume of steam than it should. This

may be due: To the ring *9* or *12* being broken and allowing steam to change into that end of the cylinder after cut-off has taken place. In this case, the broken ring will also cause a direct blow through the exhaust port after the heavy exhaust has occurred, which will continue until the exhaust port has been closed by the ring *10* or *11* as the case may be; or to the piston-rod packing in the intermediate head blowing, allowing high-pressure steam from the high-pressure cylinder to enter the front end of the low-pressure cylinder.

**43. Unequal Intervals Between Exhausts.**—When one heavy and one light exhaust occurs on a side, and the intervals are unequal, the trouble is due to a derangement of the valve motion and *not* to a blow.

---

## STANDING TEST FOR BLOWS

**44. High-Pressure Valve.**—To test for a blow in the high-pressure valve, place that side of the engine on the top quarter with the reverse lever in the center notch. Then block the drivers or set the brake, see that the starting valve is closed, remove the indicator plugs of that cylinder, and open the throttle sufficiently to insure that the packing rings are set out tight against the bushing. If steam blows from one of the indicator plugs, either ring *3* or *6* of the steam valve is blowing.

**45. Low-Pressure Valve.**—To test this valve, place the side of the engine to be tested on the top quarter with the reverse lever in the center notch. Next, remove the choke from the lubricator on that side and block the drivers or set the brake; open the starting valve, the steam valve on the lubricator, and the throttle, and then move the reverse lever so as to admit steam to either end of the cylinders. This will permit high-pressure steam to pass through the starting valve into the receiver; after the receiver has been thoroughly heated by the steam, move the reverse lever to the center notch and open the cylinder cocks of the *low-pressure cylinder only*. Also, remove the indicator plugs from that cylinder; this will empty the low-pressure cylinder of all steam.

The receiver, being once charged with steam, is kept charged through the oil-delivery pipe from the lubricator, from which the choke has been removed. Therefore, if a blow continues at the rear indicator plug, it indicates a leaky steam valve; if a blow continues from the front indicator plug, it indicates either a leaky steam valve or a blow past the piston-rod packing in the intermediate head. To determine which, test the piston-rod packing for a blow.

**46. Special Piston-Rod Packing.**—To test the piston-rod packing in the intermediate head, place that side of the engine on the top quarter with the reverse lever in the forward motion and the starting valve closed.

Block the drivers or set the brake, open the throttle and the back end of the high-pressure cylinder will be filled with steam. There will be no steam in the receiver or the low-pressure cylinder, so that if steam escapes when the front indicator plug of the low-pressure cylinder is removed, it indicates that the piston-rod packing is blowing.

**47. High-Pressure Piston Packing.**—To make a test of these rings, place that side of the engine on the top quarter with the lever in the back motion, the starting valve closed, the drivers blocked or brake set, and the throttle open. The front end of the high-pressure cylinder will thus be filled with live steam. Remove the back high-pressure indicator plug; if steam escapes, the trouble will be due to the piston packing.

**48. Low-Pressure Piston Packing.**—To test this packing for a blow, place that side of the engine on the top quarter with the reverse lever in the back motion, open the starting valve, remove the back low-pressure indicator plug, block the drivers or set the brake, and then open the throttle. This admits high-pressure steam through the starting valve into the receiver and the front end of the low-pressure cylinder. Therefore, if, after the throttle is opened, steam escapes from the back low-pressure indicator-plug opening, the piston packing is blowing.

# BALANCED COMPOUND LOCOMOTIVES

## BALDWIN BALANCED COMPOUND

### DESCRIPTION

**49. General Considerations.**—One of the greatest difficulties in designing a locomotive having two engines coupled to a single main axle with their cranks 90° apart, lies in properly balancing the revolving and reciprocating parts. The *revolving parts* comprise the cranks, crankpins, and side rods, and a portion of the main rod. The *reciprocating parts* comprise the pistons, piston rods, crossheads, and that portion of the main rods attached to the crosshead pin, which is not considered a revolving weight.

The usual method with locomotives having two main-rod connections to the wheels, is to provide each driver with a balance sufficient to fully counterbalance all the revolving parts; also, with an additional weight, known as *excess balance*, the centrifugal force of which is equal to about two-thirds of the maximum inertia of the reciprocating parts. This method makes a weight that travels in a circle balance a weight that travels in a straight line, so that it is difficult to balance the parts properly for all speeds. It is possible perfectly to balance one piston, its rod, crosshead, and connections moving in one direction, by designing the locomotive so that the other piston and its connected parts will always move in the opposite direction to the first piston. This, however, will necessitate the cranks of the locomotive being placed 180° apart, so that both will be on the dead center at the same time. In such a case the engines cannot start the locomotive if stopped on the dead center. Also, when both crankpins are on the quarters, they

will exert the full power of both pistons, which will strain the machinery and make the wheels slip at that point.

To make a locomotive practical, it must have the full power of one piston applied while its crank is on the quarter and the other crank is on the center utilizing no power. This distributes the power over the entire revolution of the wheel and equalizes the tractive effort so that the locomotive is able to start from any point in its revolution.

**50.** By the use of four cylinders, the pistons of which travel in pairs toward the opposite dead centers, as in the **balanced compound**, the power and tractive effort can be properly divided for all parts of the revolution and the reciprocating weights can be more nearly balanced. In the balanced compound locomotive, the high- and low-pressure pistons on the right side of the locomotive are connected to cranks 180° apart so that one of them is making a forward stroke at the same instant that the other is making a backward stroke; thus the two parts of each engine balance each other. The two pistons on the left side, also, are coupled to their respective cranks located 180° apart; but the relation of the cranks on the right side of the locomotive to those on the left side is the same as in a two-cylinder locomotive; that is, the right-hand engine leads the left-hand 90°. In the four-cylinder balanced compound, the high-pressure piston on the right side is 90° ahead of the left-side high-pressure piston, and 180° ahead of its own low-pressure piston. The relation of the low-pressure pistons is the same as that of the high-pressure pistons, 90° apart. Thus, the four crankpins are spaced exactly 90° apart in the circle they describe in a revolution.

The low-pressure cylinders are located outside the frames for two reasons: To have room for them and to have the low-pressure pistons attached to the crankpins in the driving wheels instead of to cranks on the axle, thus having the heavy strains from the low-pressure pistons when starting the train at a point where they will cause the least strain on the crank-axle. With one type of balanced compound, the high-pressure

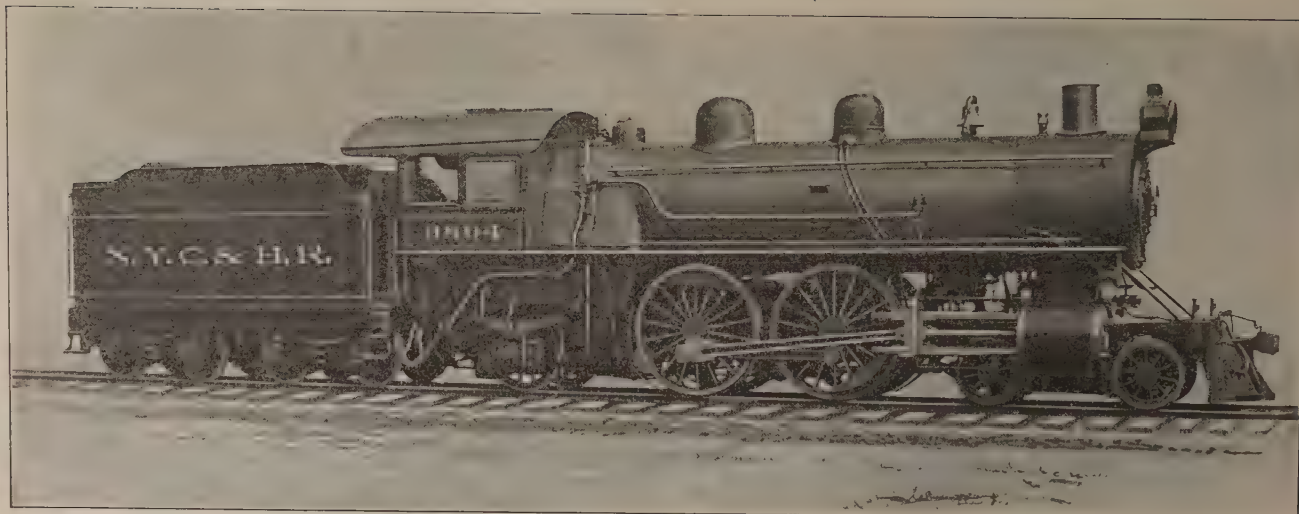
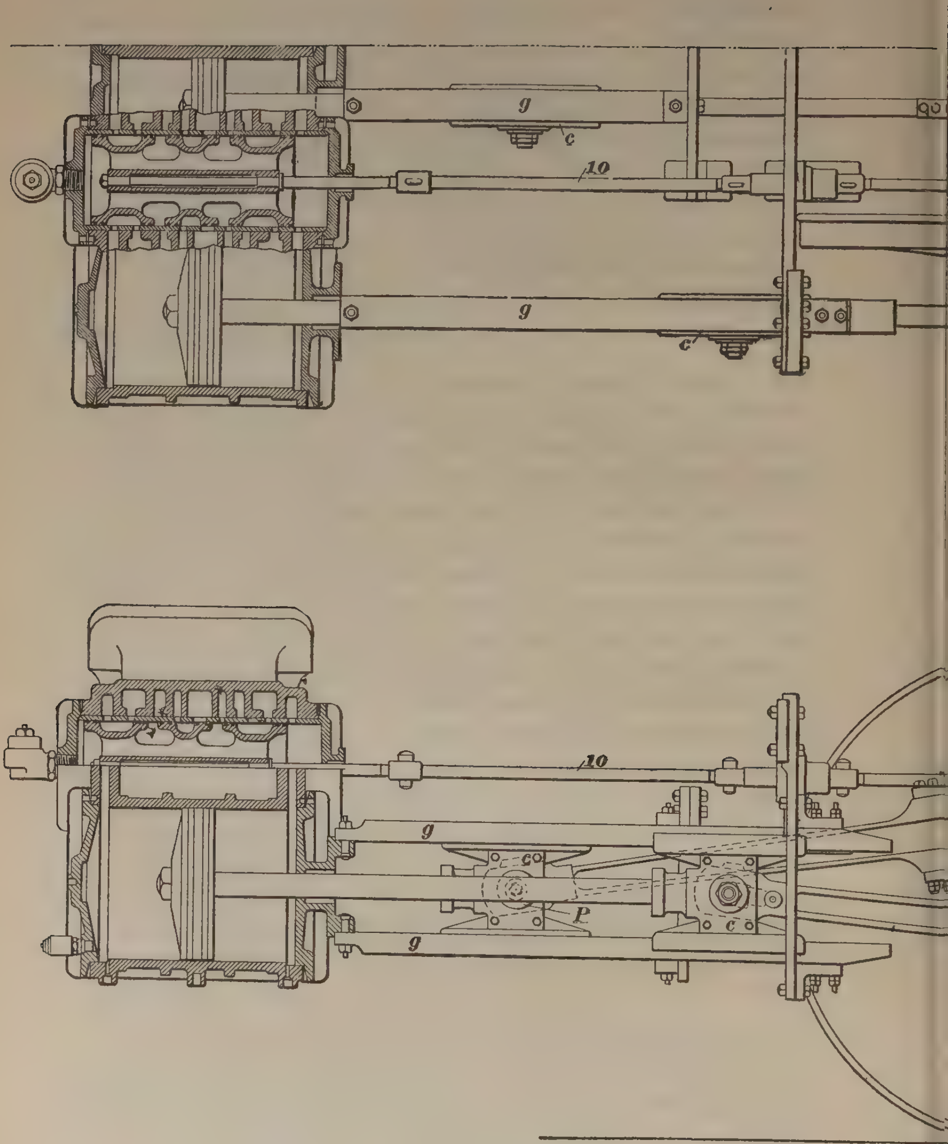



FIG. 25

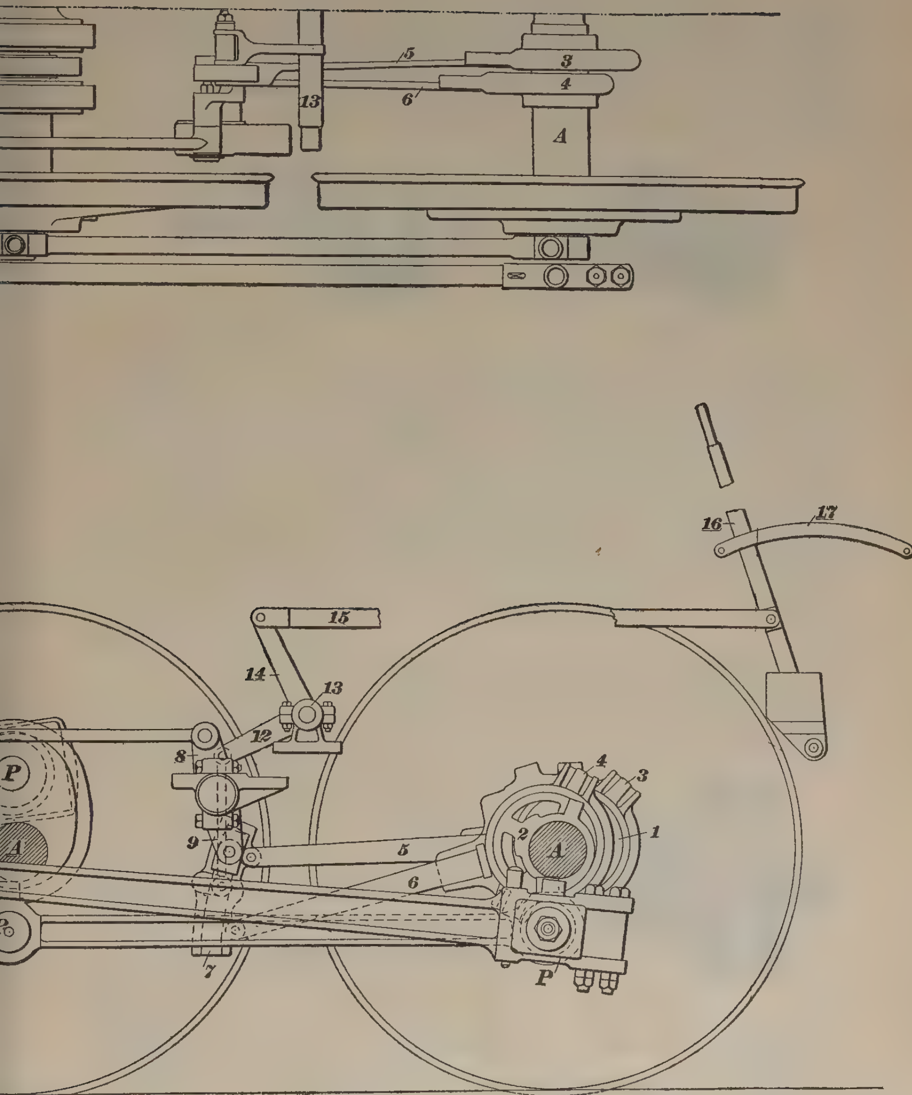
pistons are connected to the crank-axle of the first pair of wheels, and the low-pressure pistons to the crankpins in the wheels on the second pair of drivers, thus dividing the power between the two pairs of driving wheels. In another type, all four pistons are connected to the forward axle and the pair of driving wheels and its axle. Parallel or side rods are used on these engines the same as on simple engines, to connect the different pairs of driving wheels. In still another type, all four main rods are connected to the second pair of driving wheels and its axle, and the eccentrics are on the axle of the third pair of drivers.

**51. Advantages.**—The benefits of using a high boiler pressure and double expansion of the steam in two cylinders were shown in *Vauclain Compound Locomotives*. By dividing the power into four parts, as in balanced compounds, with two cylinders inside the frames and two outside, the strain on the frames is reduced; it is still further reduced by having the pistons of each engine traveling in opposite directions, which equalizes some of the strains. The strains on the frame of the engine and also on the track from the revolving counterbalance used to balance the reciprocating parts is entirely done away with. When running at high speeds, the pounding produced by improperly balanced engines in many cases bends the rails; the effect of this on bridges and on the frames of the engines can be estimated from the visible effect on the track. With this pounding of the drivers on the rail eliminated, as in the balanced compound, it is possible to increase the working load on the driving wheels. This in turn increases the adhesive force, which is the measure of the tractive force and makes possible a more powerful locomotive.

**52. Description.**—Fig. 25 is a photographic view of a Baldwin balanced compound, while Fig. 26 shows the general arrangement of the high-pressure and low-pressure cylinders, cross-heads, crankpins, main-rod and parallel-rod connections, the position of the steam chest in relation to the cylinders, the eccentrics and the valve motion for one side of the




FI


5
3
4
6
13
A
16
17
15
14
13
12
8
P
4
3
9
2
1
A
5
6
7
P

locomotive. The engine illustrated in this figure is of the type that has the high-pressure pistons connected to the crank-axle of the forward pair of drivers and the low-pressure pistons connected to crankpins in the wheels of the second pair of drivers, Fig. 26 (*a*) being a plan view and (*b*) a side

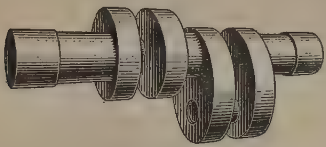


FIG. 27

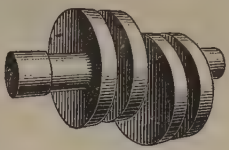


FIG. 28

elevation. Another type is made having the rods from the crossheads of the low-pressure pistons connected to crankpins in the forward pair of drivers. This makes all the crossheads the same distance from the pistons and the main rods all the same length. In both types, the arrangement of cylinders, valves, and valve motion is the same, the eccentric being located on the second axle; this arrangement leaves the crank-axle free, without the difficulty of placing the eccentrics between the cranks.

Several designs of crank-axles are used on balanced locomotives. The one shown in Fig. 27 is of nickel steel, forged in one piece with a 4-inch hole drilled through the center of the crankpins and a steel pin forced in by hydraulic pressure and riveted over the crank-cheeks to make this part of the crank stronger. Steel bands are also shrunk around the outside diameter of the crank-cheeks. The one shown in Fig. 28 is called a *built-up disk axle*. It is made of nine pieces—three parts of the axle proper, the two crankpins, and the four crank-disks. These are forgings that are made of the proper size, then forced together, keyed, and riveted. This design brings the grain of the metal in the proper direction to resist the strains. Fig. 29 shows a built-up axle

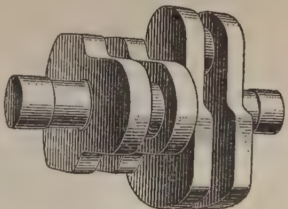


FIG. 29

with counterweights so arranged that all the weights are balanced in the same plane.

Fig. 30 shows the arrangement of the cylinders and steam chests. One high- and one low-pressure cylinder with their

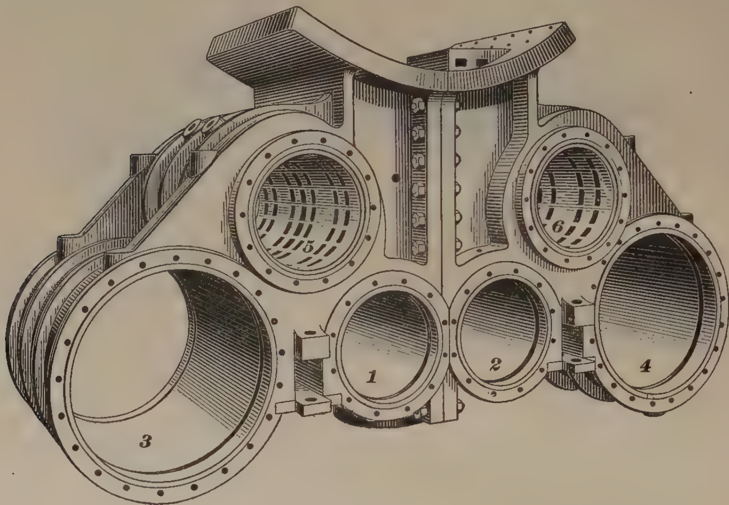



FIG. 30

steam chests is in each half of the cylinder saddle, the two parts being bolted together as shown. The valve bushing, Fig. 31, after being machined to its proper size and the ports

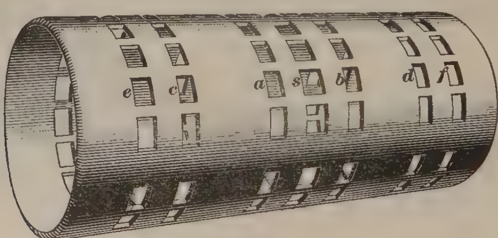



FIG. 31

all dressed to their right shape, is pressed into place in the cylinder saddle. In Fig. 30, *1* and *2* are the high-pressure cylinders; *3* and *4*, the low-pressure cylinders; *5* and *6*, the valve bushings.

Fig. 31 shows the ports in the valve bushing. The middle row of ports *s* is for live steam. The ports *a* and *b* at each side of port *s* are the steam ports to the front and back ends of the high-pressure cylinder. The next two ports, *c*, *d*, are the exhaust ports for the low-pressure cylinder, which lead to the final exhaust passage *E*, Fig. 33. The outside ports, *e f*, are the steam ports for the low-pressure cylinder.

Fig. 32 is the piston valve, which is hollow with openings at *x* and *y* through which the steam from the high-pressure cylinder, after it has expanded once, is exhausted into the interior of the valve and thence passes by the end of the

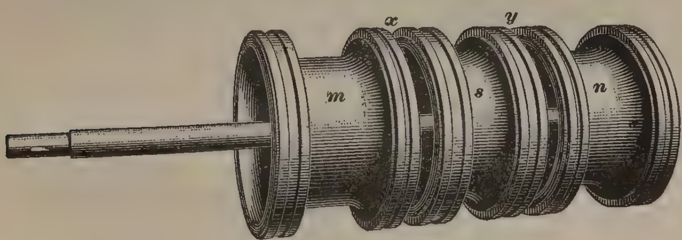


FIG. 32

valve through either port *e* or *f*, Fig. 33, into the low-pressure cylinder to be expanded again. *m* and *n* are exhaust cavities in the valve. The steam from port *e*, Fig. 33, can pass through *m* into port *c* and thence to final exhaust *E*; or, with the valve in the position shown, steam from *f* can pass through *n* into *d* and then to the final exhaust *E*.

Fig. 33 shows the course of the steam when the high-pressure piston is making the forward stroke. The live steam from *S* passes through the cavity of the valve *s*, through port *b* into the back end of the high-pressure cylinder; at the same time, the steam that has done its work in the forward end of this cylinder passes out through port *a*, through the opening *x*, into the interior of the valve *v*, thence past the end of the valve into port *e* and the forward end of the low-pressure cylinder. Exhaust steam from the back end of the low-pressure cylinder flows through port *f* and the cavity *n* of the valve into port *d* and to the final exhaust *E*. The arrows indicate the course of the steam from the time it enters

the high-pressure steam chest at $S$, until it exhausts to the atmosphere at $E$.

The operation of the starting valve $V$ is the same as that used with the Vauclain compound. The valve is piped to connect the two ends of the high-pressure cylinder so that

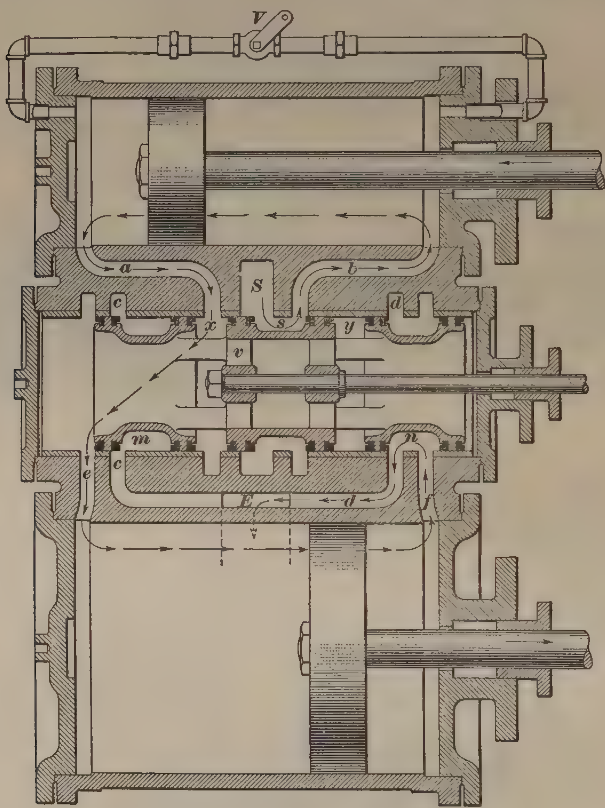



FIG. 33

when the valve is open, steam can flow from one end to the other and thus admit live steam through the interior of the valve $v$ to the low-pressure cylinder.

**53.** Fig. 34 shows the relative positions of the four pistons at six points in a complete stroke. Beginning with

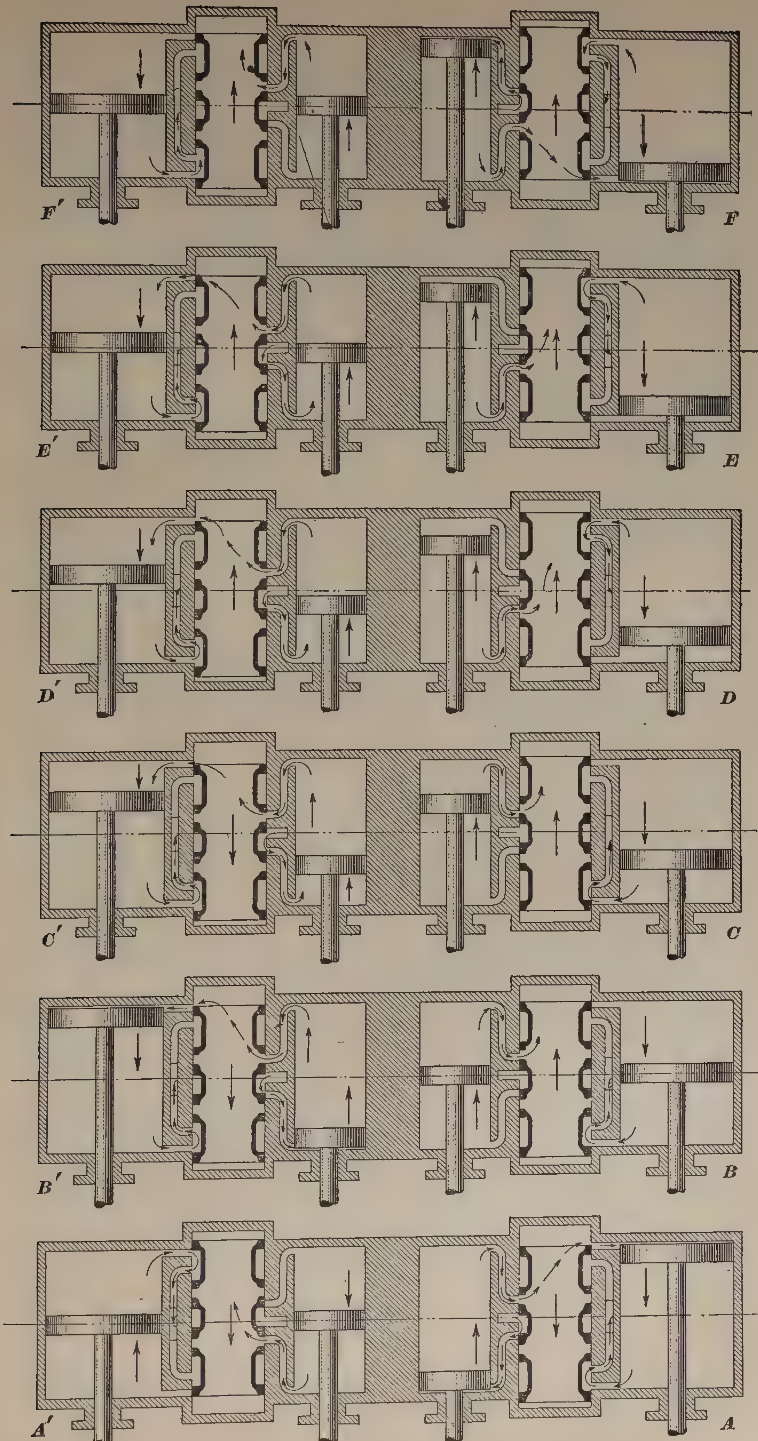



FIG. 34

position $A$, the high-pressure piston on the right side is just beginning the forward stroke and the low-pressure piston the backward stroke. The valve is moving in its backward stroke. Its position is that of admitting live steam to the back end of the high-pressure cylinder. The steam from the front end of this cylinder is being exhausted through the valve across into the forward end of the low-pressure cylinder. At the same time, the exhaust port is open to allow steam from the back end of the low-pressure cylinder to pass to the final exhaust port and thence to the stack. The piston of the left-hand high-pressure cylinder $A'$ is in the middle of its stroke approaching the back center, just a quarter of a turn behind the right-hand piston in $A$. Also, the low-pressure piston in $A'$ is a quarter of a turn behind the one in $A$. The valve for $A$ has the live-steam port open just the amount of the lead and is moving backwards toward the end of its travel for the half stroke cut off. The valve for $A'$ has just cut off live steam from the forward end of the high-pressure cylinder $A'$ and the back end of the low-pressure cylinder. The flow of steam through the exhaust ports on this side can readily be traced by the arrows.

The next position $B$ shows the right-hand high-pressure piston in the middle of its forward stroke. The valve has moved far enough to cut off the steam from both cylinders, the exhaust steam from the forward end of the high-pressure cylinder passing into the valve chamber, which acts as a receiver. The exhaust port for the back end of the low-pressure cylinder is still open and steam is passing to the final exhaust. $B'$ shows the pistons on the left side at the ends of their stroke and the valve in position to admit steam to both cylinders, as explained for the right side in position $A$. The various positions of the pistons and valves are shown in the diagram up to $F$ and $F'$, and the operation during an entire stroke can readily be made out by following the indications of the arrows. In this diagram the exact position of the pistons in relation to each other, as affected by the angularity of the main rod, is not taken into account.

### OPERATING

**54.** In starting a train with a Baldwin balanced compound, see that the cylinder cocks are open. Also, the starting valve should be open so that the low-pressure cylinder will be supplied with steam. This valve is only intended for use in starting a train, or in cases where the train is about to stall on a grade. It should not be used at speeds greater than 4 miles per hour, and should always be closed so that the engine is working compound before the reverse lever is hooked up. Neglect to close the starting valve after the train has been started, or continuously to operate the engine with the starting valve open, will result in excessive repairs and waste of fuel and will make the engine logy. However, the starting valve should remain open during the time the engine is switching.

The reverse lever should be handled exactly the same as for a piston-valve simple engine, only the starting valve must be closed before beginning to hook back the reverse lever. The last notch on the quadrant is located so that steam will be cut off at half stroke in the high-pressure cylinders; if with the reverse lever in that notch more power is being developed than is required, partly close the throttle to regulate the speed. No engine with piston valves should be reversed at speed.

In drifting down a long grade, the reverse lever should be carried as near the corner as practicable so as to insure large port openings to the valves for full relief from the cylinders. Open the starting valve and crack the throttle slightly; the steam will then help keep the cylinders lubricated and cool.

The water in the boiler should not be carried any higher than is necessary for safety. Also, when working steam, the high-pressure cylinder requires most oil; whereas, while drifting, the low-pressure cylinders should receive the most.

## BREAKDOWNS

**55. Broken High-Pressure Main Rod.**—In the event of a high- or low-pressure main rod's breaking, no serious damage having been done to the other parts, take down the broken rod, block its crosshead securely at the back end of the guides, disconnect the valve rod on that side, move the valve ahead, and clamp it securely in such a position that the valve will open the front steam port of the high-pressure cylinder a small amount and admit a little steam into that cylinder. The low-pressure main rod on the side causing trouble may be left up, but special attention must be given to keeping the low-pressure cylinder well lubricated in order to prevent cutting the cylinder walls. Steam admitted to that cylinder will assist very materially in lubricating the walls, so that the starting valve must be left open in order that steam can pass from the front end of the high-pressure cylinder through the starting valve and the receiver into the back end of the low-pressure cylinder. The indicator plugs on the disabled side should be removed or the cylinder cocks blocked open; if the engine stops on the dead center, the cylinder cocks on the disabled side should be closed, or the indicator plugs replaced, as the case may be; the pressure will then accumulate and move the engine off the center. The cocks should then be again blocked open. The engine can be run in with one side, taking such part of its train as can be handled.

**56. Broken Low-Pressure Main Rod.**—In the event of a low-pressure main rod's breaking, no serious damage having been done to the other parts, take down the broken rod, block its crosshead securely at the back end of the guides, disconnect the valve rod on that side, move it back, and clamp it securely in such a position that the valve will open the back steam port of the high-pressure cylinder and admit a little steam to that cylinder. The high-pressure main rod may be left up, but its cylinder must be kept well lubricated, the steam being admitted to assist in lubricating

the cylinder. The indicator plugs on the disabled side should be removed or the cylinder cocks blocked open. The engine can then be run in on one side.

**57. Broken Side Rod.**—Some engines have all four main-rod connections on the forward pair of drivers and the eccentrics on the second axle. On such engines, a broken side rod between the first and second pairs of drivers will necessitate taking down that rod and its mate. The engine will have to be towed in.

Other engines have two main rods operating the forward pair of drivers, and two operating the second pair, the eccentrics being on the second axle. If the side rod between the first and second pairs of drivers breaks, the side rods will have to be taken down and the engine prepared to be towed in. If the engine is six-coupled and the rear section of side rods breaks, only that rod and its mate need be taken down.

**58. Broken Piston Rod or Broken Piston.**—When a piston rod breaks, it almost invariably causes the front cylinder head to be knocked out; if it breaks close to the piston, and, in this event, the crosshead is not damaged or the piston rod bent, disconnect the valve rod and clamp the valve so as to just open the steam ports to the cylinders a small amount. The main rod can be left up, because the crosshead will carry its front end and the stuffingbox will carry the front end of the piston rod, but the rod swab should be kept oiled. If the rod breaks at the crosshead, but does not injure the crosshead, disconnect the valve rod and clamp the valve as before. In this case, also, the main rod can be left up. Should the crosshead be so damaged as to be unserviceable, disconnect the main rod and block or secure the crosshead, to keep it stationary. If a part of the piston cracks off and the cylinder will not be injured by the piston moving in its cylinder, proceed as in the case of a piston rod broken at the piston. If the cylinder is liable to be further damaged by the moving piston, disconnect the main rod also.

The cylinders on the disabled side must be kept well lubricated so as to avoid cutting.

**59. Broken Valve Stem.**—If a valve stem breaks, remove the broken pieces and clamp or block the valves in such a position that they will just open the steam ports a small amount and admit a little steam into the cylinders. The starting valve should be open. Leave up the main rods, but keep the cylinders on that side well lubricated.

---

## RUNNING TEST FOR BLOWS

**60. Two Heavy Exhausts.**—If the two exhausts from a side are heavier than the normal exhaust, the receiver pressure on that side is higher than it should be. This may be due: To the rings *5*, *6*, *7*, or *8* leaking or being broken, allowing live steam to blow into the receiver direct; to the high-pressure piston packing rings being badly worn or broken; to the starting valve leaking; or to a cracked bridge or loose bushing between port $S$ and port $a$ or $b$. Therefore, if two heavy exhausts occur on one side of the engine, test that side for the above defects.

**61. Two Light Exhausts.**—Two light exhausts from a side indicate either a low receiver pressure or worn or broken low-pressure piston rings. The low receiver pressure may be due: To badly worn or broken valve packing rings *1* and *2*, *3* and *4*, *9* and *10*, or *11* and *12*, which would allow receiver steam to escape to the exhaust, producing a continuous blow; or to a cracked bridge or loose valve bushing between ports $e$ and $c$ or $f$ and $d$, either of which would cause a blow to the exhaust on one stroke of the piston only. Care must be taken not to confuse two light exhausts from one side with two heavy exhausts from the other side.

**62. One Heavy Exhaust.**—If the exhaust beats occur at the proper intervals, but one exhaust on a side is heavier than the normal, it indicates that one end of the low-pressure cylinder on that side is receiving either a higher pressure or a greater volume of steam than it should. A broken valve

ring *1* or *12*, Fig. 35, will cause this trouble. The heavy exhaust will be followed after a short interval by a direct blow from the receiver to the exhaust that will continue until

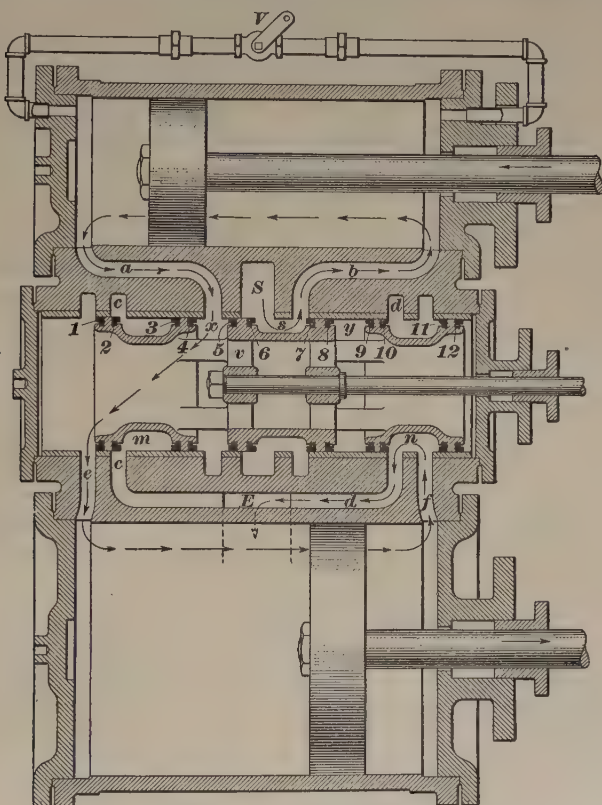



Fig. 35

the exhaust port is closed at compression. A slipped eccentric will cause one heavy and one light exhaust on its side, but the exhaust beats will not occur at the proper intervals.

---

## STANDING TEST FOR BLOWS

**63. High-Pressure Valve.**—The high-pressure valve is that part between the packing rings *5–6* and *7–8*. To test these rings of either valve, place the main pin on that side

of the engine on the bottom quarter with the reverse lever in the center notch so that the valve will be in mid-position and covering the steam ports to the high-pressure cylinder. Block the drivers or set the brake, see that the starting valve is closed, remove the indicator plugs or open the cylinder cocks to the high-pressure cylinder, and then open the throttle. Steam blowing from either indicator-plug opening indicates that the rings at that end of the high-pressure valve are blowing.

**64. Low-Pressure Valve and Piston.**—The low-pressure valve is in two parts; that part, Fig. 35, between the packing rings *1* and *4*, and that between the rings *9* and *12*. To test a low-pressure valve, place the main pin on that side of the engine on the bottom quarter with the reverse lever in the forward corner and the starting valve open. In this position of the valve, the back steam port *b* to the high-pressure cylinder is connected to the steam-supply port *S*, and as the starting valve is open, there is direct communication between port *S* and the receiver. Next, block the drivers or set the brake, remove the back indicator plug of the low-pressure cylinder, and then open the throttle. Steam will pass from port *S* through port *b*, the starting valve and port *a*, into the receiver and the front end of the low-pressure cylinder. Therefore, if a blow occurs at the exhaust and steam escapes from the back indicator-plug opening, it indicates either a leak past the valve, a cracked bridge or loose bushing between ports *e* and *c*, or a leak past the low-pressure piston. To determine which is at fault, open the front low-pressure cylinder cock and move the valve so as to cover the steam ports. If the blow continues, the valve is at fault; if it stops, the trouble is in the bridge, bushing, or piston. Whether the piston, bridge, or bushing is causing the trouble can be readily determined when the engine is running slowly, since defective piston packing rings will blow on both strokes of the piston, while a defective bridge or bushing will blow only on one stroke. With the engine standing, you can distinguish between these

defects by moving the reverse lever to the other corner, replace the removed indicator plug, and remove the one from the other end of the low-pressure cylinder. Open the throttle, and if the blow continues the fault is in the piston; if it has stopped, the bridge or bushing is defective.

**65. High-Pressure Piston Packing.**—To test a high-pressure piston, place the main pin on that side of the engine on the bottom quarter with the reverse lever in the front corner and the starting valve closed. Block the drivers or set the brake, remove the indicator plug to the front end of either the high- or low-pressure cylinder and then open the throttle; this will admit steam to the back end of the high-pressure cylinder, as in Fig. 35, and the escape of steam from the indicator plug opening will denote a leak either past the piston or past the high-pressure valve. To determine which, test the high-pressure valve; if it is not leaking, the trouble must be in the piston.

## BALANCED COMPOUND OF THE AMERICAN LOCOMOTIVE COMPANY

### DESCRIPTION

**66. General Arrangement.**—The balanced compound designed by Mr. F. J. Cole and built by the American Locomotive Company is shown in Fig. 36. The illustration shows the low-pressure cylinder with its valve chest directly above it; the valve chest for the high-pressure cylinder extends in front with the steam pipe above and connecting with the center of the valve chest. This figure represents the engine as originally built. In the later type, the starting valves and by-pass valves are incorporated in the cylinder saddle as shown in the succeeding illustrations. The high-pressure cylinders are not shown as they are between the frames, their pistons being connected to the forward driving axle by means of cranks in the axle. The low-pressure pistons are connected, in the usual way, to crankpins in the

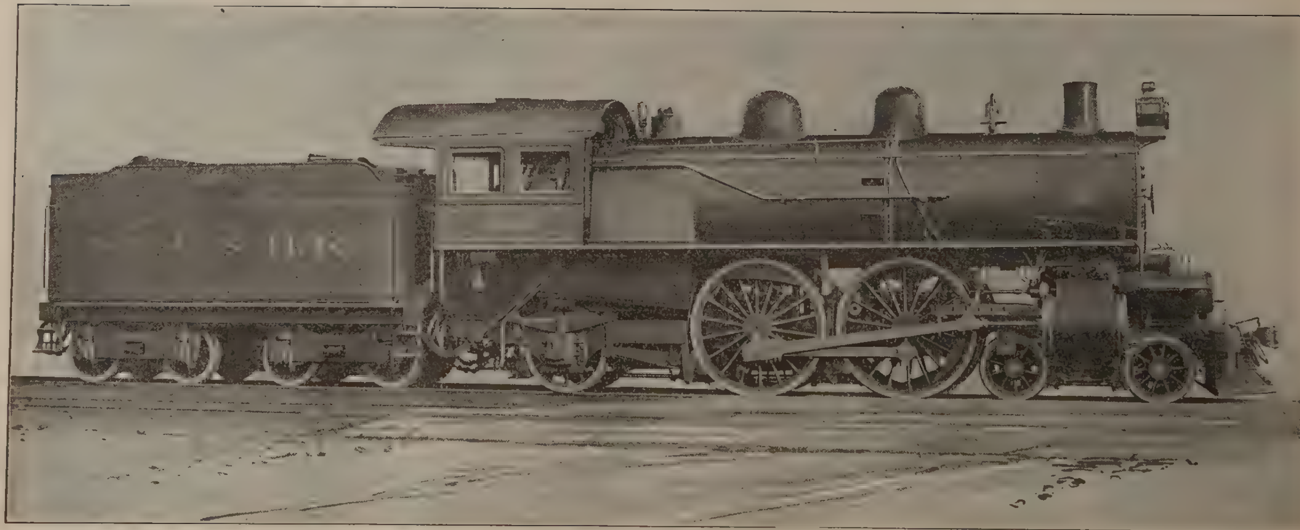


FIG. 36

wheel centers of the back pair of drivers. The high- and low-pressure pistons on each side are connected to cranks 180° apart so that as one piston is making a forward stroke the other is making a backward stroke and are thus balanced. The engine on the left side of the locomotive is 90° or one-quarter of a turn behind the one on the right side, so that when one side is on the center and developing no power to turn the driving wheels, the other side is on the quarter and developing its greatest power. This arrangement brings the four crankpins exactly 90° apart on the axles. The position of the high-pressure cylinders relative to the low-pressure cylinders is shown in Fig. 37, which is a plan view of the right side of the locomotive. The valve chest is located exactly above the frame and above the two cylinders on that side; it is not shown in the figure, but its position is shown in Fig. 38, which gives a sectional view of the right half and end view of the left cylinders and valve chamber. It also shows the arrangement of the steam passages, frame, and the location of the high-pressure cylinders. The illustration, Fig. 38, is taken looking from the front of the engine backwards. Referring to Fig. 37, *1* and *2* are the high- and low-pressure cylinders, respectively; *5* and *6*, their pistons; *8* and *9*, the main-rod connections; *10* the crankpin connection for the right-hand high-pressure piston, and *12* the main pin for the right low-pressure piston. The valve rod for the right side is shown at *13*, the forward-motion eccentric straps at *15*, and the backward motion straps at *14*.

Fig. 38 shows an end elevation and section in which *3* and *4* are the ends of the left-side high- and low-pressure cylinders; *1* and *2*, the high- and low-pressure cylinders on the right side; *7* and *8*, the valve chambers for the two sides as shown. The left side of the cylinder saddle is shown in full; the right side is sectioned on the line *A B*, Fig. 37, and the front part removed, so that the high-pressure cylinders are not seen.

Fig. 39 is a diagrammatic view of the high-pressure cylinder *1*, low-pressure cylinder *2*, and the valve bushings *7* and *8* for the low- and high-pressure valves. The illustration

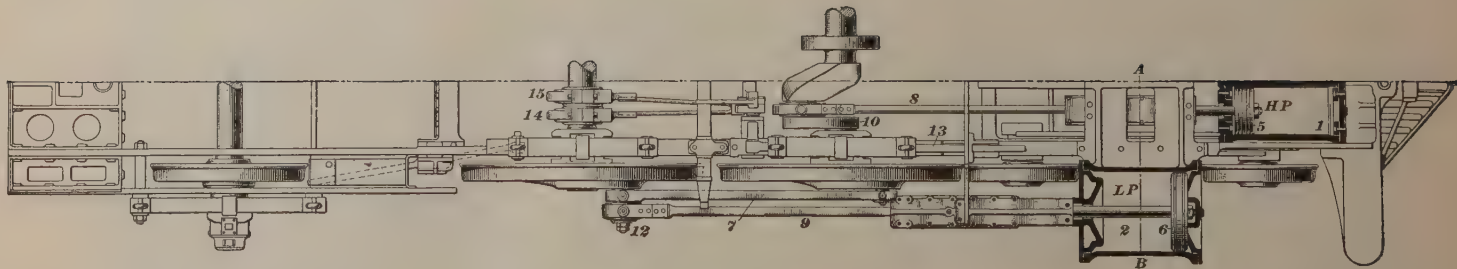



FIG. 37

shows the pistons near the beginning of their stroke; the valve so admitting steam that the high-pressure piston is making its forward and the low-pressure piston its backward stroke. The course of the steam is indicated by the arrows; it is assumed that the engine has made a complete revolution so that the steam has been properly distributed in both cylinders. The valve *9* is an inside admission valve, while valve *10*

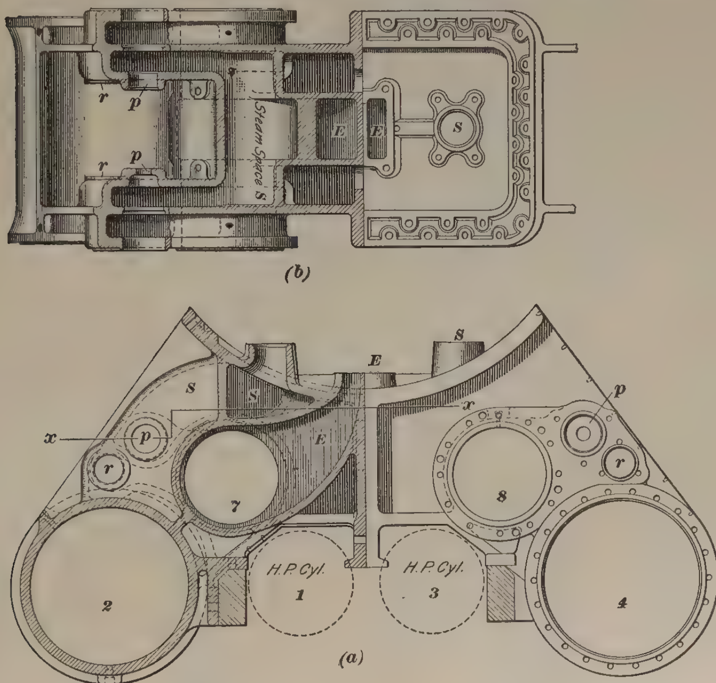



FIG. 38

is an outside admission valve, both being constructed alike. In the figure, live steam enters at $S$, thence passing through port $a$ into the back end of the high-pressure cylinder *1*, forcing that piston forwards. At the same time the steam from the front end of this high-pressure cylinder is exhausting through port $b$ into the receiver and thence it passes through port $d$ into the front end of the low-pressure cylinder *2*, forcing that piston on its backward stroke. Steam

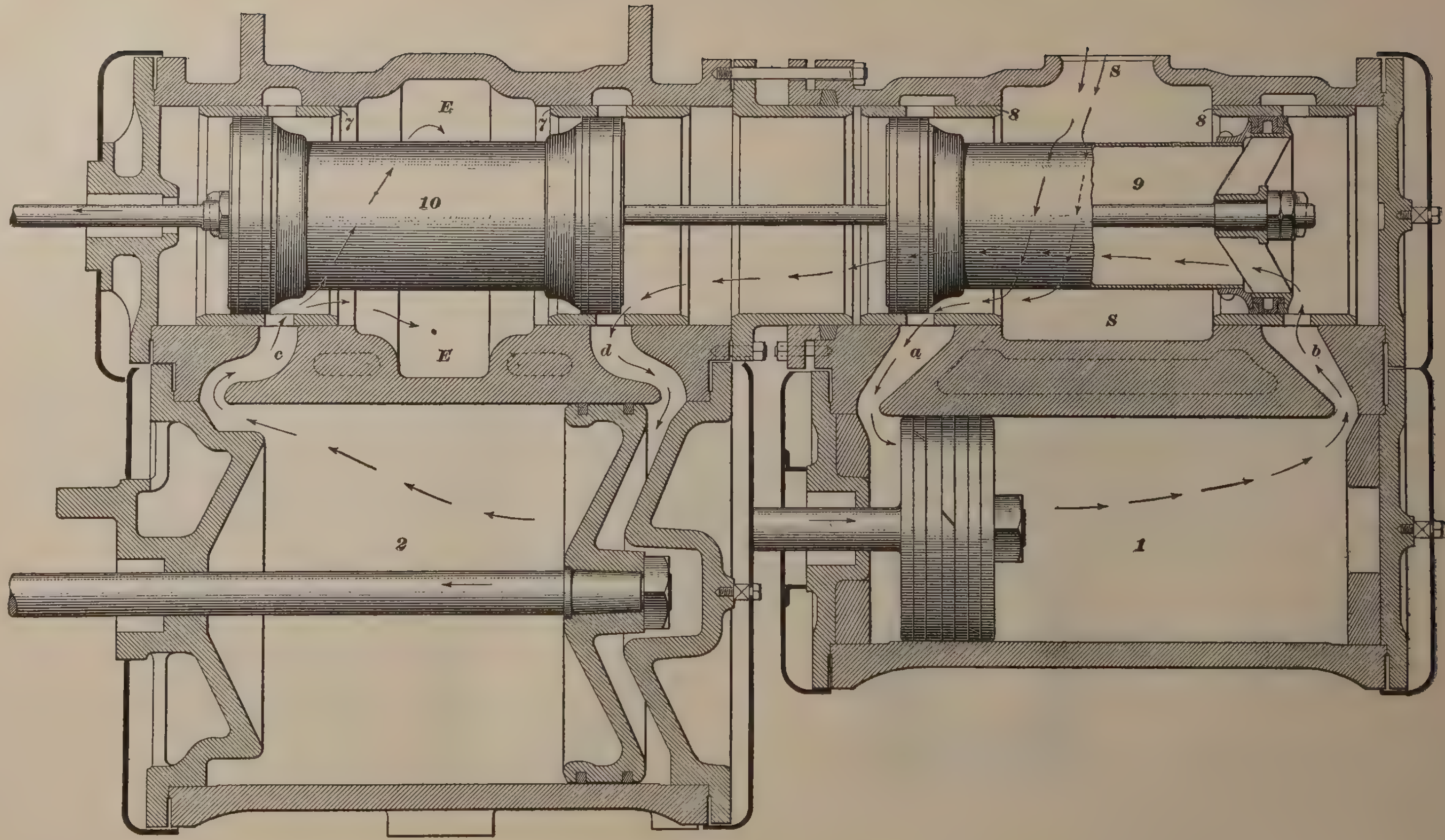



FIG. 39

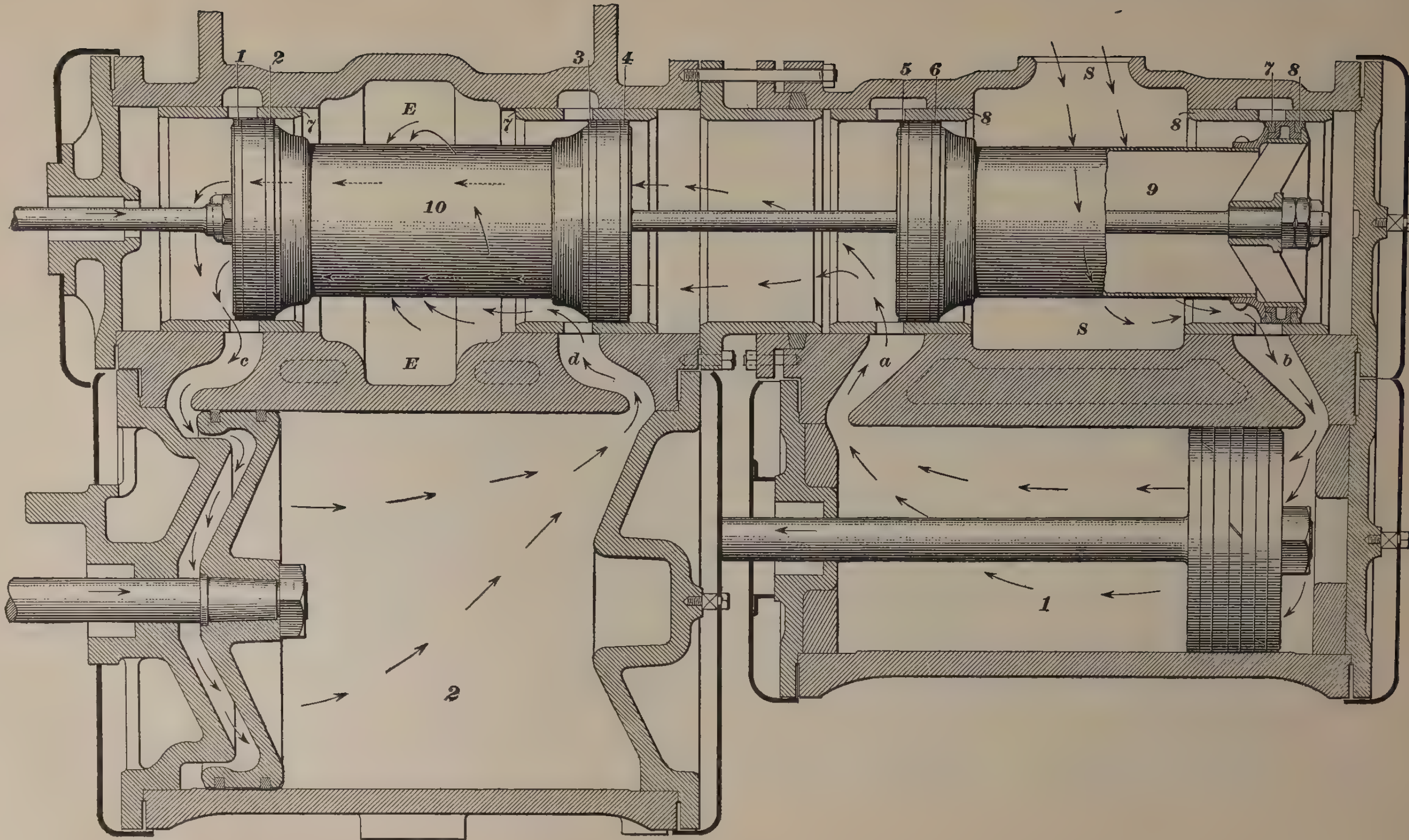



Fig. 40

from the back end of the low-pressure cylinder is passing out through port *c* and the cavity of the valve *10* to the final exhaust *E*.

Fig. 40 shows the pistons and valves in the positions for the return stroke; that is, the high-pressure piston is making the backward stroke and the low-pressure piston its forward stroke. The arrows indicate the course of the steam to and from the cylinders.

**67. Details of Starting Valve.**—The combined starting valve and reducing valve used with this engine is shown in Fig. 41, in which *5* is the starting valve and *6* the reducing valve. The starting valve *5* forms a steam-tight seat at *a* and controls communication between chamber *A* and the atmosphere through the passage *c* and the drip pipe. The valve is connected to the valve rod *4*, which is provided with a yoke *3* by means of which the valve is opened and closed. The lever *2* is secured to the shaft *1*, which is connected to a lever in the cab by means of which the shaft is rotated in either direction. Moving the lever *2* forwards opens valve *5*; moving it backwards closes the valve.

The reducing valve *6* forms a steam-tight seat at the two points *7* and *8*. The cast-iron rings *9* and *10* are to prevent steam blowing through the chamber *B*, passage *d*, and the drip pipe to the atmosphere when the valve is unseated.

The space between the valve faces *7* and *8* is always filled with live steam from the boiler when the throttle is open. The valve face *7*, however, presents slightly more area to the pressure of the steam than the face *8*, so that there is always a tendency for the valve to open. The end *z* of the valve makes a sufficiently loose fit so that chamber *A* is charged to the same pressure as chamber *y* and the receiver when the valve *5* is seated. When valve *5* is open, chamber *A* is maintained at atmospheric pressure.

**68. Operation of Starting Valve.**—The starting valve and its connections are shown diagrammatically in Fig. 42. It will be seen that chamber *x*, Fig. 41, is directly connected to the live steam space *S*, Fig. 38, by the passage *x*, Fig. 42,

while chamber $y$ is connected to the receiver by the passage $y$. Now if steam is turned on while valve *5* is closed, it will flow

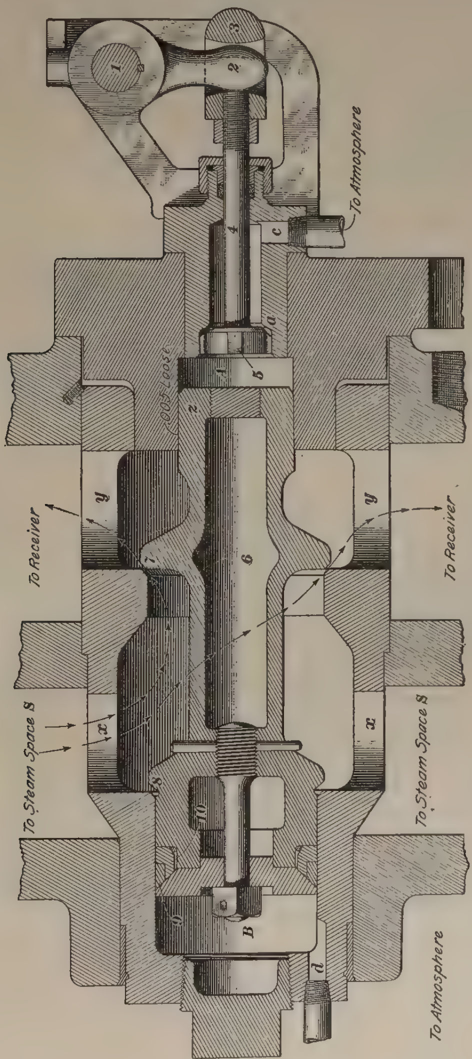



FIG. 41

into chamber $x$ and unseat valve *6*. Steam will then flow through the passage $y$ into the receiver, and into chamber $A$.

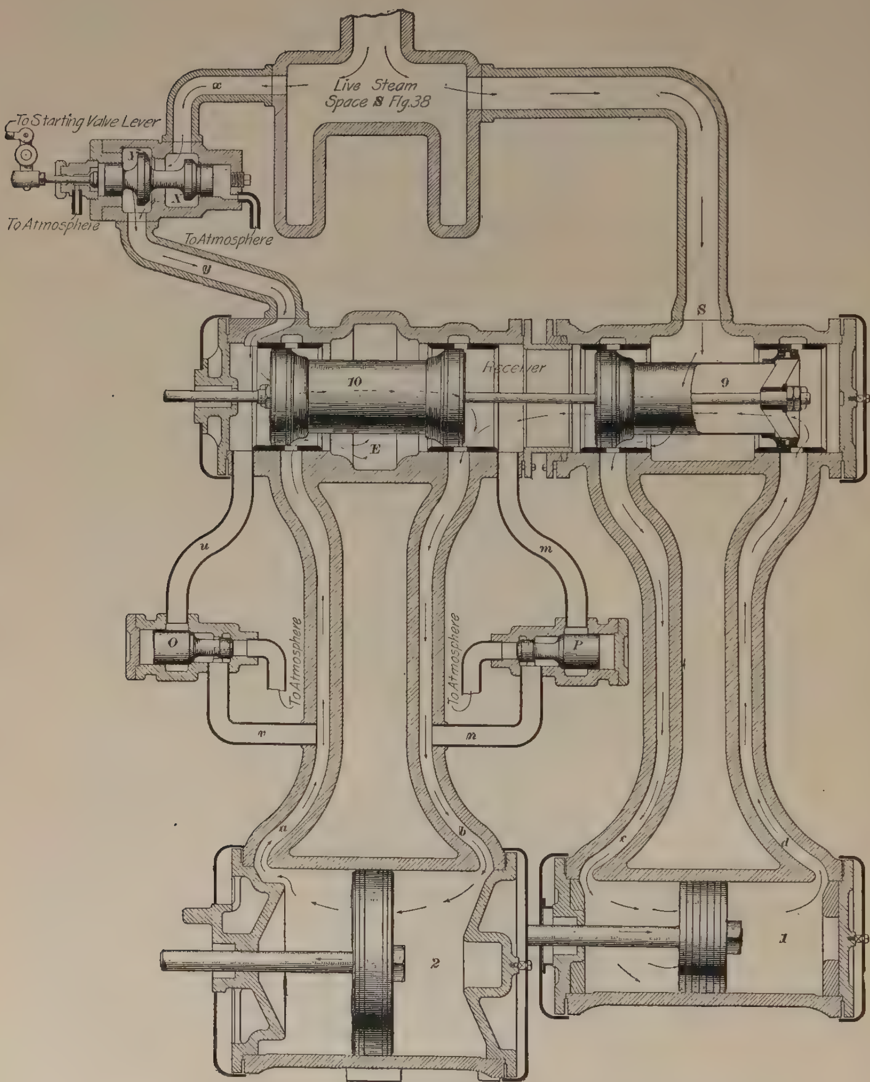

Live Steam
Space S Fig.38
To Starting Valve Lever
To Atmosphere
To Atmosphere
Receiver
To Atmosphere
To Atmosphere

FIG. 42

The additional area of the valve exposed to steam pressure in chambers *y* and *A* is such that the valve will be closed when one-fourth boiler pressure, 50 pounds, is obtained in the receiver. Any reduction of pressure in the receiver below 50 pounds will cause the valve to open and raise the pressure to that amount.

If valve *5* is open, there is only atmospheric pressure in chamber *A* and the pressure in chamber *y* and the receiver will have to be raised to 80 pounds before the pressures acting to close the valve are sufficient to close it.

**69. Details of By-Pass Valve.**—The combination by-pass and relief valve used with this engine is shown in section in Fig. 43. The valve *6* seats at both *7* and *8*; the former seat prevents receiver steam escaping into the low-pressure cylinder, and the latter prevents steam escaping

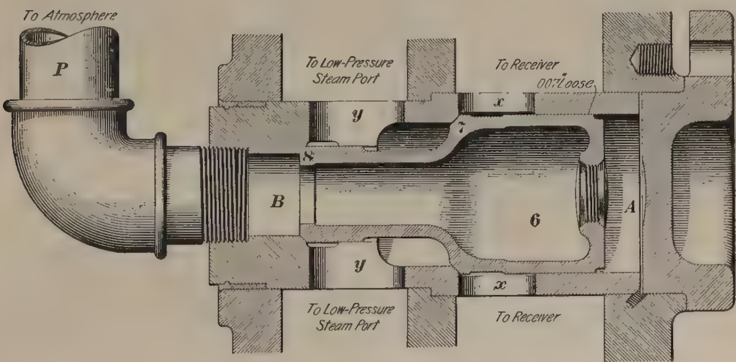



Fig. 43

from the low-pressure cylinder to the atmosphere through pipe *P*. The end of the valve makes a loose fit so that chamber *A* is charged to the same pressure as chamber *x*.

These by-pass valves are exactly similar in construction and operation to those used in the tandem compound. In this case, however, they are placed in the cylinder saddle, whereas in the tandem they are placed in a cage on the outside.

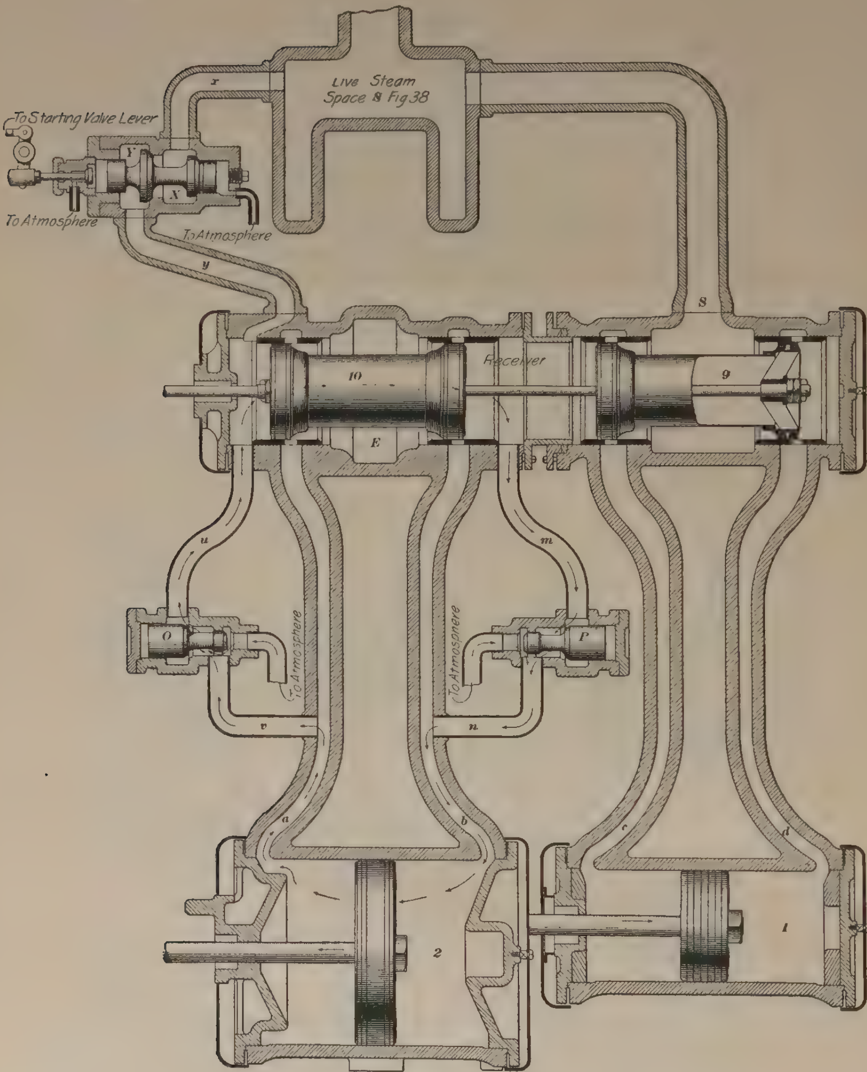

Live Steam
Space 8 Fig 38
To Starting Valve Lever
To Atmosphere
To Atmosphere
Receiver
To Atmosphere
To Atmosphere

FIG. 44

**70. Operation of By-Pass Valve.**—The by-pass valves *O* and *P* and their connections are shown diagrammatically in Fig. 44, from which it will be seen that the passage *x*, Fig. 43, of the valve connects with the receiver, while the passage *y* connects with the steam passage to the low-pressure cylinder. When the engine throttle is open, live steam from the receiver charges chamber *A*, Fig. 8, and holds valve *6* to its seat.

When the engine is drifting, a vacuum tends to form in the receiver, therefore in chamber *A* of the by-pass valve, and atmospheric pressure through pipe *P* forces by-pass valve *6* off its seat. The arrows, Fig. 44, indicate the way the air relieves the vacuum in the low-pressure cylinder when the engine is drifting. The high-pressure cylinders are not provided with these valves.

The areas of valves exposed to pressure in chambers *y* and *x* are so proportioned that any excess of pressure in chamber *y*, due to water in the cylinder or otherwise, will force valve *6* off its seat and thus relieve the pressure.

## OPERATION

**71. Working Compound.**—When this type of locomotive is started compound, the starting lever in the cab is in such a position that the starting valve *5*, Fig. 41, is closed. Steam entering the live-steam space *S*, Fig. 42, passes through the reducing valve as indicated by the arrows. The reducing valve, with starting valve closed, maintains about 50 pounds in the receiver, so that the low-pressure cylinder is provided with live steam at that pressure with which to start the engine.

The high-pressure cylinder receives its steam supply direct through the steam pipe *S*, as indicated by the arrows; the exhaust from the high-pressure cylinder discharges into the receiver for use in the low-pressure cylinder. After two or three revolutions of the drivers, the exhaust steam from the high-pressure cylinder supplies the low-pressure cylinder, the reducing valve being held shut.

**72. Starting Simple.**—In starting a heavy train or in starting a train on a grade where the full power of the engine is required, the starting lever in the cab should be moved so as to open valve *5*, Fig. 41. This maintains chamber *A* at atmospheric pressure so that 80 pounds pressure is obtained in the receiver through the reducing valve, which gives the locomotive a much greater starting force than is obtained from compound position.

## OPERATING

**73.** Under ordinary conditions, the engine will start the train without the use of the starting valve. The reducing valve automatically gives about 50 pounds in the receiver without the use of the starting valve, so that the latter need be used only when the full power of the engine is required in starting a train. After three or four revolutions of the drivers, the starting lever can be closed.

In starting, the cylinder cocks must be kept open until the cylinders are warmed up and the engine under good headway. Any defect in the cylinder cocks or their rigging should be promptly reported.

Also, it is important that the water be not carried so high in the boiler that it will be carried over into the cylinders, on account of the piston valves used, which cannot lift like a slide valve and thus relieve the cylinders of water.

When drifting at speed with steam shut off, the reverse lever must not be dropped below the 12-inch notch until the speed is reduced below 15 miles per hour, when it may be eased down and just before stopping, dropped into the corner ready for starting.

The low-pressure valves and cylinders only require about half as much oil as the high-pressure when using steam, but when drifting down long grades they require much more.

## BREAKDOWNS

**74. Broken High-Pressure Main Rod.**—In the event of a high-pressure rod breaking and no serious damage having been done to other parts, take down that rod and

block its crosshead securely at the back end. Disconnect the valve rod on that side, move the valve forwards until it opens the back steam port to the low-pressure cylinder a small amount and clamp the valve securely in that position. The steam admitted through the starting valve and receiver into the low-pressure cylinder will help lubricate the walls. The low-pressure main rod may be left up, but its cylinder must be kept well lubricated. Remove the indicator plugs or block open the cylinder cocks on that side, and proceed, using one side of the engine.

**75. Broken Low-Pressure Main Rod.**—If no other serious damage is done when this breakdown occurs, take down the broken rod, block its crosshead securely at the back end of the guides, disconnect the valve rod on that side, move the valve back and clamp it securely in such a position that it will open the back steam port to the high-pressure cylinder a small amount so as to admit a little steam to help lubricate the cylinder. The high-pressure main rod on that side may be left up, but the high-pressure cylinder must be kept well lubricated. The indicator plugs on the disabled side should be removed, or the cylinder cocks blocked open; the engine can then be run in with one side, taking such part of the train as can be handled.

**76. Broken Side Rod.**—This engine has two main rods operating the forward pair of drivers and two operating the second pair, the two pairs of drivers being connected by side rods and the eccentrics placed on the second axle. If the side rod of such an engine should break, the broken rod and its mate must be removed and the engine prepared to be towed in.

**77. Broken Piston Rod or Broken Piston.**—When a piston rod breaks, it almost invariably causes the front cylinder head to be knocked out; if it breaks close to the piston, and, in this event, the crosshead is not damaged or the piston rod bent, disconnect the valve rod and clamp the valves, so as to just uncover the steam ports a little and admit a small amount of steam into the cylinders. The main rod can be left

up, because the crosshead will carry its front end, and the stuffingbox will carry the front end of the piston rod, but the rod swab should be kept oiled. If the rod breaks at the crosshead, but does not injure the crosshead, disconnect the valve rod and clamp the valves as before. In this case, also, the main rod can be left up. Should the crosshead be so damaged as to be unserviceable, disconnect the main rod and block or secure the crosshead, to keep it stationary. If a part of the piston cracks off and the cylinder will not be injured by the piston moving in its cylinder, proceed as in the case of a piston rod broken at the piston. If the cylinder is liable to be further damaged by the moving piston, disconnect the main rod also.

The cylinders on the disabled side must be kept well lubricated so as to avoid cutting.

**78. Broken Valve Stem.**—In the event of this part's breaking, remove the broken parts, and clamp or block the valve in such a position that it will just open the steam ports enough to admit a small amount of steam into the cylinders to assist lubrication. Leave the main rod up, but keep the cylinders on that side well lubricated.

---

## RUNNING TEST FOR BLOWS

**79. Two Heavy Exhausts.**—Two heavy exhausts from a side indicate too high a receiver pressure. This may be due to: The valve ring *5*, *6*, *7*, or *8*, Fig. 42, leaking or being badly broken, or to the starting valve or by-pass valve leaking; to the high-pressure piston packing rings being badly worn or broken; or to a loose high-pressure bushing. Therefore, if two heavy exhausts occur on a side, test that side for the above defects.

**80. Two Light Exhausts.**—Two light exhausts from the side indicate either a low receiver pressure or badly worn or broken valve packing ring *1*, *2*, *3*, or *4*, Fig. 42, which will allow receiver steam to escape to the exhaust, producing a blow; or to a loose low-pressure valve bushing. Do not

confuse the cases of two light and two normal exhausts with two normal and two heavy exhausts, thinking that the normal exhaust is the heavier one.

**81. One Heavy Exhaust.**—If the exhaust beats occur at the proper intervals, but one exhaust on a side is heavier than normal, it indicates that the end of the low-pressure cylinder on that side is receiving a greater volume of steam than it should; this will be due to a broken low-pressure valve ring *1* or *4*, Fig. 42. The heavy exhaust will be followed, after a short interval, by a direct blow from the receiver on the exhaust, which will continue until the exhaust port is closed at compression. A slipped eccentric will cause one heavy and one light exhaust, but the exhaust beats will not occur at proper intervals.

---

### STANDING TEST FOR BLOWS

**82. High-Pressure Valve.**—To test a high-pressure valve, place the low-pressure main pin on that side of the engine on the bottom quarter with the reverse lever in the center notch so that the valve will be in mid-position and covering the steam ports to the high-pressure cylinder. Block valve *6* of the starting valve, Fig. 41, closed so as to keep steam out of the receiver; block the drivers or set the brake, remove the indicator plugs or open the cylinder cocks to the high-pressure cylinder, and then open the throttle. Steam blowing from either indicator-plug or cylinder-cock opening indicates that the ring *6* or *7*, Fig. 42, at that end of the high-pressure valve is blowing.

**83. Low-Pressure Valve.**—To test a low-pressure valve, place the low-pressure main pin on that side of the engine on the bottom quarter with the reverse lever in the center notch so that the valve will be in mid-position. Block the drivers or set the brake, open the starting valve, remove the indicator plugs of the low-pressure cylinder or open the cylinder cocks, then open the throttle. Steam blowing from either indicator-plug or cylinder-cock opening indicates that

the ring *1* or *4*, Fig. 42, at that end of the low-pressure valve is blowing.

**84. High-Pressure Piston Packing.**—To test a high-pressure piston, place the low-pressure main pin on that side of the engine on the bottom quarter with the reverse lever in the forward corner, block the starting valve closed, block the drivers or set the brake, remove the indicator plug or open the cylinder cock of the front end of the high-pressure cylinder, then open the throttle. This will admit steam to the back end of the high-pressure cylinder and the escape of steam from the indicator-plug or cylinder-cock opening will indicate a leak past the piston or high-pressure valve. To determine which, test the high-pressure valve; if this is not leaking, the trouble is in the piston.

**85. Low-Pressure Piston Packing.**—To test the low-pressure piston packing, place the low-pressure main pin on that side of the engine on the bottom quarter with the reverse lever in the forward corner, open the starting valve, block the drivers or set the brake, remove the indicator plugs or open the cylinder cock on the back end of the low-pressure cylinder, and then open the throttle. The receiver will immediately be charged with steam at 80 pounds pressure, which will pass through the front steam port into the front end of the low-pressure cylinder. The escape of steam from the indicator-plug or cylinder-cock opening will denote leaky packing rings or low-pressure valve. To determine which, test the valve.

# TRAIN RULES

(PART 1)

## INTRODUCTION

**1. Purpose of Train Rules, Etc.**—The **Standard Code of Train Rules** adopted by the American Railway Association is composed of: (1) a set of general rules stating the duties of employes; (2) specific definitions of terms used in the code; (3) a system of watch inspection to provide that all the timepieces shall agree as to the correct time, so that train movements can be regulated with exactness; (4) an explanation of the authority given by the timetable; (5) rules for the proper use of the various signals—fixed, movable, and audible; (6) the classification of trains, and rules for their movement by train orders; and finally, (7) forms of train orders with explanations as to how trains should proceed under them, and their rights under each authorized form of train order.

**2. By Whom Code Is Prepared.**—This Code has been revised, simplified, and its language amended from time to time by the Association (which is composed of the superintendents and managing officers of the numerous railroads using the Standard Code), until it is now set forth in as clear terms as can be made, the meaning of each rule being so plain that there can be no misunderstanding by any of the parties that may be working by its provisions.

The authorized version of April, 1902, for both single- and double-track operations, is given at the end of this Section, and the student should refer to it for definite answers to all questions submitted to him.

**3. Thoroughness of Code.**—By way of particularizing the information contained in the Standard Code, over five hundred different facts are stated in relation to the operation of trains; of which we enumerate 5 items in the General Notice: 11 general rules; 23 definitions of terms used in the code; 59 rules relating to time-tables, signal rules, classification of trains, and the movement of trains on single track and 59 rules for the same purposes for double track; 23 rules for the movement of trains by train orders on single track and 23 for double track; and, lastly, 13 forms of train orders for use on single track and 12 forms for use on double track; over 200 principal subjects in all, many of which are subdivided.

In addition to the Standard Code, there are many special rules put forth by railroad companies to suit conditions on their lines, but these we do not take up in this Section; we teach the Standard Code only, which is arranged to suit general, not special, conditions.

The rules for double-track operations are identified by the initial letter D prefixed to the number of the rule.

From the above enumeration, the student will understand why such a large number of examination questions are needed to bring out his knowledge of the Standard Code.

**4. Prime Requisites in Railroading.**—The first requisite in all train movements is *safety*, which calls for constant care on the part of each employe.

Next to safety come *promptness and exactness of despatch*, by which is meant leaving exactly on time, moving at the uniform standard speed, as provided for in the schedule or train orders, reaching all meeting points at the time specified by the schedule or rules, and passing all stations at the exact time shown in the schedule.

Unless exact time is kept, other trains than your own will be delayed, which will interfere with the operation of the whole system.

*Exactness of movement* is an important factor in securing safety of movement; for if a train comes along at the exact

moment it is due, it is more easily looked out for than if it is late and is thereby delaying other trains, which may attempt to do work not authorized by the rules, but which is permissible when under the protection of a train order or signal by a flagman. The use of a special order or signal presupposes that the attempted movement has an element of danger in it.

**5. Duties of Employes.**—The General Notice that prefaces the Standard Code states that the fact of a man's entering or remaining in the service is regarded as an assurance of his willingness to obey the rules—this being essential to the safety of passengers, employes, and property. It is further demanded that the service shall be faithful and intelligent, and all duties courteously performed. This is a rule that pertains to all lines of business, and an employe can only look for promotion when he follows the rules closely and shows that he has a capacity for greater responsibilities. To thoroughly understand and be guided by the general rules, a copy must be in your possession for reference. Some of the standard rules have more than one form, as for instance, Rules 4 and 221; some companies use one form, and some the other, so the student should understand both.

You should be thoroughly acquainted with all changes made from time to time by these special rules and instructions. When the special rules conflict with or countermand any previous rules, the latest special rule on that subject must be obeyed. These special rules are issued in the form of: (1) bulletin notices; (2) printed circulars; (3) printed on the time-table; or (4) as train orders; and the places where these special notices are usually posted should be examined before each trip, to make sure that none are overlooked.

If there is any doubt as to the meaning of any rule, either general or special, the matter should be at once referred to the proper authority for a clear explanation.

So much is required of employes in the train service that examinations are necessary to test their qualifications, as well as to see that all understand the rules alike and have

the ability to carry them out. All persons employed in any service on trains are subject to the rules and special instructions, and as the safety of all may depend on the care and ability of any one of them, it is expected that all employes will give their assistance toward carrying out all of the rules and instructions.

The safety of the train and its load depends on each employe having a clear idea of his duties and a clear head to perform them; for that reason, the use of intoxicants while on duty is prohibited by the Code, and in several of the states by law, which makes such use a misdemeanor. As it is difficult to draw the line at the exact point when the use of liquor interferes with a man's faculties, the line is drawn clear down at the bottom, and frequenting places where liquor is sold or drank is a sufficient cause for dismissal from the service—such dismissal being backed up by public opinion, which gives all law its vitality. As the use of tobacco is offensive to many passengers and patrons of the company, it is prohibited in and about passenger trains and depots.

To distinguish the employes charged with duties connected with the passenger service, they are required to wear badges and a prescribed uniform, and since the company is judged by the appearance of its employes, self-respect will dictate that all be neat and tidy in their dress and polite in their manners.

As there are times when the property of the company may be endangered and no one especially charged with its care be present, the rule calls on all to look out for the protection of such property, whether in their particular line of duty or not.

# TRAIN RULES

## DEFINITIONS

**6. Various Kinds of Trains.**—A **train** is defined as an engine, or two or more engines coupled together—whether any cars are attached or not—displaying markers. It is to be understood that **markers** are signals that are carried at the rear to show that the vehicle bearing them is the last one in the train. Thus, a marker on a single engine running head first would be a green flag by day and a green light by night, showing toward the head end and also toward the side, and a red light showing toward the rear, and located on each side of the rear end of the tender. When the engine is running backwards, the markers are carried on each side of the pilot, the red light showing in the opposite direction to which the engine moves. On a train of cars, the markers are displayed from each side of the rear car of the train, and are notice to persons concerned that the train is all there.

A **regular train** is one that is represented on the time-table. It may consist of sections, each of which runs on the same schedule, either displaying signals for a following train or following signals displayed for them by a preceding train. Rule 20 refers to the carrying of such signals and explains what signals are to be carried and where they are to be carried.

An **extra train** is one not represented on the time-table. In train orders, any extra train, except a work train, is designated as an "extra"; a work train has the title of work extra, the name in a measure defining its character. This is further mentioned in Form H of Train Orders.

**Extras** consist of one section, and each extra has some identifying mark to distinguish it from other extras. In the Standard Code, the number of the engine drawing the train

is used for this purpose; in the case of a double-header, it is customary to use the numbers of both engines in the train order.

A **superior train** is one having precedence over other trains. There are three methods of giving a train precedence: (1) by right, which is conferred by train order, and can be given or taken away by competent authority; (2) by class, which is conferred by the time-table and lasts during the life of that time-table, unless taken away by a train order, as in the case of annulling a train; and (3) by direction, which is also conferred by the time-table, and affects only trains of the same class, on single track, in their relation to each other. See Rule 81.

**Right** is superior to either class or direction; right is given by a train order which is to be obeyed instead of the regular rule with which it may conflict. A **train order** is a special instruction that changes the regular rule; therefore, rights given by train order are superior to class rights. A train order that gives rights to a train that the latter does not receive from the time-table, or that restricts the rights of the train, must be obeyed to the letter.

Trains of a superior class have precedence over those of an **inferior class,** as shown on the time-table, and over all extras unless the time-table rights are changed by train order.

Trains of the same class, on single track, have their rights according to direction specified in the time-table. In the absence of any train orders or special instructions to the contrary, the train of the same class not having the right by direction must keep off the time and out of the way of the train having this right. Form C of Train Orders is used to change these rights from one train to the other.

The **time-table** is the authority for the movement of regular trains, subject to the rules. It contains the classified schedules of trains with special instructions relating thereto. Another definition of a time-table is the general law governing the time of all regular trains at all stations. Thus, it will be seen that the time-table should not be confused with the general train rules, which are not a part of the time-table, but

are only printed on the same sheet of paper, or in connection with it, for convenience in consulting them.

**Special rules** relating to the schedule of a train are distinct from the general rules for train movements.

The **schedule** of a train is that part of a time-table that prescribes: (1) its class, which shows its rights in relation to other trains; (2) its direction, which shows its right as to other trains of the same class moving on single track; (3) its number, which is the name by which we identify it; and (4) its movement, which shows its leaving and arriving times at different stations. On the schedule of each train are found the signs that indicate regular stops, flag stops, or stations where the train does not stop.

Usually, the tracks over which trains are operated are known as *main tracks*, *sidings*, and *yards*. A **single track** is defined as one on which trains are operated in both directions by time-table or by train orders. This explanation applies also to a **main track.** A **double track** is defined as two main tracks, on one of which the current of traffic is in a specified direction, and on the other track in the opposite direction.

The **current of traffic** is defined as the direction in which trains will move on a main track under the rules. Rule D–151 in the Code specifies which track is used for a certain direction.

A **station** is a place designated by name on the time-table, at which a train may stop for traffic, or to enter or leave the main track; or from which fixed signals are operated. From this definition it is understood that a station may be a place where there are numerous sidings, or it may not have any siding. In some cases it has only a fixed signal and the machinery for operating it, but in every case it has a name on the time-table.

A **siding** is an auxiliary track for permitting the meeting or passing of trains; it is limited to the distance between two adjoining telegraph stations. We are in the habit of calling a track used for unloading or loading cars a siding also, but the above definition is in relation to train movements only.

A **fixed signal** is one having a fixed location and indicates a condition affecting the movement of a train. Train-order boards and signals, semaphore signals at block stations, or at railroad crossings or junctions, belong to this class.

**Yards** are systems of tracks, within defined limits, provided for the making up of trains, storing of cars, and other purposes, over which movements not authorized by time-table or train order may be made, subject to prescribed signals and regulations. Of course, it is understood that main tracks and sidings for passing trains can be, and are, within the limits of established yards, and the rules, both general and special, are so arranged as to facilitate as much as possible the yard work without delaying in any way the operation of trains on the main line.

**Yard engines** are those assigned to yard service and working within yard limits. Yard engines carry different signals from those on main-line engines when at work as such (see Rule 18). The rules give them certain special rights inside yard limits.

A **pilot** is a person assigned to a train when the engineman or conductor, or both, are not fully acquainted with the physical characteristics or running rules of the road, or portion thereof over which the train is to be moved. A pilot is held responsible for the safety and proper running of the train, provided that his instructions are obeyed by the crew in charge of the engine and train. He is expected to look out for meeting points on the time-table and on the orders, and to give the engineman running the engine sufficient notice so that he may handle the train properly. The pilot's name should appear on train orders addressed to any train that he has in charge. See Rule 204.

**7. Time Standard.**—In order that all train movements controlled by the time-table or that have the element of correct time in consideration may be exactly carried out, it is necessary that all employes shall have the same standard of time. To secure this, at a certain hour of the day, the correct standard time is sent to all offices on the line simultaneously

by telegraph, and all watches used by conductors and enginemen must be compared with certain of these clocks (designated as *standard clocks*), before starting out on a trip, to ascertain if they show the correct time. It is not sufficient that the watches show the correct time after being compared with the standard clock, but they must also keep good time until the next chance for comparing them. Only watches that are in good order will do this, and to know whether or not they are in good order, it is necessary to have them inspected by a competent person at regular intervals, just as an engine needs close inspection at regular intervals, in order to know whether it is in good condition. An engine, to do good work, must be well built from good designs and receive proper attention subsequently; so, also, must a watch be well built and well taken care of. For that purpose, there has been devised a system of regular inspection that all watches in train service must pass, a certificate being granted to that effect, this certificate running for a certain length of time, after which the watch must be again inspected. A form that can be filled out showing the date when watches are compared is used for registering this comparison. Conductors and enginemen should compare time with each other just before starting out on a trip. In case they do not have access to a standard clock to get the correct time before starting out, it is customary to ask for the correct time by wire from a standard clock. These methods vary so much on different roads that the employe should first ascertain exactly how it is done on the road on which he is employed and then follow the instructions literally.

## TIME-TABLES

**8. General Explanation.**—Every time-table has a **number** by which it is identified, and also the date and hour at which it goes into effect. From the moment it goes into effect it supersedes the preceding time-table, which should be destroyed at once in order to prevent any chance of its being substituted or exchanged for the new one. This

prevents the use of an outlawed time-table. For the purpose of more easily distinguishing a new time-table from the old one, it is sometimes printed on paper of a different color, so as to attract attention. This, however, is not done on all roads; therefore, the employe should note carefully the number of the time-table in his possession, to be sure that it is one of the last issue. The time of day at which a new time-table goes into effect is usually set at an hour when a change of time will make as little trouble, in the movement of trains, as possible.

A receipt for the new time-table should be signed by both enginemen and conductors when it is issued to them, and it is customary, unless the receipt is on file in the despatcher's office, to acknowledge by wire the receipt of a new time-table before starting out on the first trip that may come on the time of the new table. This is for the information and protection of the officer in charge of train movements.

In regard to the rights of trains at the time the new time-table supersedes the old one, they are prescribed by Rule 4 and there are two forms used that specify the rights of regular trains at that moment. Form A provides that a train of the preceding time-table thereupon loses both right and class, and can thereafter proceed only by train order. No train of the new time-table shall run on any division until it is due to start from its initial point on that division, after the time-table takes effect.

Form A of Rule 4 takes away both train-order and time-table rights from all regular trains on the road at the time the new time-table goes into effect, and makes them get train orders as extras before they can move any farther. They should endeavor to be at a telegraph office at the time the new time-table takes effect, so as to get orders without delay.

**9.** Form B of Rule 4 provides that each time-table, from the moment it takes effect, supersedes the preceding time-table, the same as Form A, but, in the treatment of regular trains on the road at the time the new time-table takes effect,

it is much different. It states that a train of the preceding time-table retains its train orders and takes the schedule of the train of the same number on the new time-table. A train of the new time-table that has not the same number on the preceding time-table shall not run on any division until it is due to start from its initial point on that division, after the time-table takes effect. Thus, under the rights given by Form B of Rule 4, any regular train, where number and time are not altered, can run right along—off one time-table on to the next one. If the time is later on the new time-table than on the old one, the train will have to wait during the interval, as no train can run ahead of time, because it has no existence as a train until its time begins. If, on the other hand, its time is earlier on the new table than on the old one, it will be due at the exact time given on the new table, and inferior trains will have to keep out of its way. This train can make up the interval just the same as any delayed train.

In the case of a train of the old time-table, whose number and schedule do not appear on the new table, its rights of all kinds die with the old time-table. A train created by the new time-table cannot run on any division until it is due to start from its initial point on that division after the new time-table takes effect.

Some companies use one form of Rule 4 and some another, and some make a number of amendments not found in either Forms A or B. Carefully study the time-table of your own road when answering questions in regard to this rule.

**10. Government of Trains by Time-Table.**—If a new train is timed to start from an initial point on any division before the time-table takes effect, that train cannot run on that division until the next day. If it is timed to start from the initial point after the time-table takes effect, it can run on that division on that day, even though it may be a train that runs over several divisions and is timed on them previous to the time-table taking effect. For instance: We will suppose that there are three divisions of

the same road, which we will call the First Division, the Second Division, and the Third Division. A new time-table takes effect at 12 noon, and train No. 4 is timed to start out on the First Division at 9 A. M., arrive at the initial point on the Second Division at 11:30 A. M., and leave at the same time; to leave the Second Division at 2 P. M., and start out on the Third Division at 2:05 P. M. This train cannot run on the First nor on the Second Divisions, because it is timed to leave on each before 12 noon, the time that the new time-table takes effect. But it can run on the Third Division as a regular train, because its leaving time at the initial, or beginning, station is at 2:05 P. M., which is after the time that the new time-table takes effect; therefore, trains that No. 4 has rights over will have to get train orders or else keep out of No. 4's way.

By an **initial station** is meant the station at which a train begins its trip on a division. It is the first station on that division at which the train is timed to leave on its schedule.

**11. Times Given on the Table.**—On the time-table, not more than two times are given for a train at any point. Where one time is given it is, unless otherwise indicated, the leaving time; when two, they are the arriving and the leaving time. Of course, at a terminal, where a train finishes its trip on any division, the time is the arriving time. Rule 92 contains something further on this subject.

**12. Indicating Meeting and Passing Points.**—The schedule meeting and passing points of a train are indicated by figures in full-faced type, thus, **3:15**. In order to attract attention to this matter, both the arriving and leaving times are in full-faced figures when both are meeting or passing times, or when one or more trains are to meet or pass it between those times; it is therefore necessary to look on the time-table for one or more trains there, if this double sign is on the time-table. There are other ways in which attention can be called to this matter of meeting more than one train at any point, the method adopted not being the same for all roads using this Code.

To facilitate reading the time-table, and make it brief, signs are placed before the figures on the schedule:

"s" indicates a regular stop.

"f" indicates flag stop for passengers or freight.

"¶" indicates stop for meals.

"l" indicates leave.

"a" indicates arrive.

The days on which the trains are due to run are usually printed in the same column with the time, and the class of the train appears on the time-table at the top of the columns.

---

## VISIBLE SIGNALS

**13. General Remarks.**—In order that employes whose duties require that they give signals can do this work properly, they are held responsible for providing themselves with suitable flags of the prescribed color for use in daytime, and with lamps of the prescribed color for use by night. The night signals are to be displayed from sunset until sunrise, and at the same time the flags should also be used if the daylight is bright enough so that the flags will be plainly visible. In foggy or dark weather, during the day or when other conditions obscure the day signals, the night signals should be used in addition to the flags. *Red* is the universal color for stop, *green* is generally used for caution, and *white* is a safety color, although on many roads white is no longer used as a safety color at night. The colors used for caution and safety on the different roads vary, yellow being used by some.

**14. Lamp Signals.**—A hand lamp, when stationary in a yard, should not be mistaken for a fixed signal of the same color. The effectiveness of lamp signals depends as much on their positive motion in a prescribed manner as on the color of the signals, and it should be borne in mind that both hand signals and lamp signals must be so made as to leave no doubt as to their meaning.

When swung across the track, it means stop at once.

If raised and lowered vertically, it means proceed.

If swung vertically in circle across the track when train is standing, it means back up; it is customary to continue giving this signal at intervals while the train is backing up.

If swung in a full-arm circle across the track while the train is running, it is a signal that the train is parted, and such signal should be repeated until a response is given by the engineman. The engineman should give the break-in-two signal immediately when he discovers that the train has parted, and continue giving it at intervals until he is certain that the rear-end men know of it.

If swung horizontally in a small circle when the train is standing (the movement being similar to that of a brake wheel), it is the signal to apply the air brakes; the signal to release brakes is given by holding the lamp or hand at arm's length above the head.

It is important that this signal should not be confused with the signals sometimes given to start ahead; as a signal to release the air brakes does not mean go ahead, the brakes must be inspected to be sure that they are all right before leaving. Any object waved violently by any one on or near the track must be regarded as a signal to stop. Persons not in the service of the company may see some danger to the train, and as they do not always know the code of proper signals, any violent signal must be taken for stop; so ascertain the cause before proceeding.

**15. Fusee Signals.**—A fusee is an extra danger or caution signal. It is used by being lighted and placed on or near the track. A fusee on or near the track showing red is a stop signal and must not be passed until it burns out, as it denotes that a train has lately passed that point, which you must look out for, or that some condition of the track requires a stop or caution in subsequent movements. If it shows green, it is a caution signal. Fusees ordinarily burn 5 and 10 minutes, during which time the preceding train, if there is one ahead, can get to a safer place. So much depends on the effectiveness of a fusee as a signal, that those who are required to use them should, by practice and

observation, learn the best and most effective method for dropping them from the rear of a moving train, to insure their burning after being dropped. After a fusee is lighted, a few seconds' time should be given before dropping to allow the fire to burn through the primer into the live chemical, the burning of which produces the red or green light. Ordinarily, the best method for dropping a fusee from the rear of a moving train is to incline it at an angle of about 45°, with the point downwards and toward the train and let it slip from the hand.

---

## AUDIBLE SIGNALS

**16. Whistle Signals.—Audible signals** are any signals given by sound, such as those given by the steam or air whistle, torpedoes, etc. The whistle signal given by the steam whistle of the engine should be clear and distinct, and the blast should be of the proper length, as specified in Rule 14, with the proper interval of silence between the blasts. Signals intended to be heard a long distance should be given louder and longer than those for a short distance. Some of the signals are prescribed by law, and must be given with the proper intervals, so that they can be easily understood and not be confused with signals given for another purpose. For instance: The signals prescribed for a public crossing at grade should be given clear and distinct, and not with some of the blasts running together; this should be done in order that this signal may not be mistaken for the break-in-two signal or the signal to denote that signals are being carried for a following train. A careless use of signals impairs their effectiveness.

One short distinct blast means stop—apply brakes.

Two moderately long blasts with a short interval between them means release brakes.

One long blast followed by three short blasts is a notice for the flagman to go back and protect the rear of the train.

Four long blasts is the signal to call in the flagman from west or south.

Five long blasts is the signal to call in the flagman from east or north.

Three long blasts, when running, means that the train has parted. This signal must be repeated until answered from the train, as prescribed by Rule 12. Also, it must be used in answer to a signal from the train that the train has parted.

Two short blasts close together is an answer to any signal given to the engineer that is not otherwise provided for. This signal is sometimes called the all-right signal.

Three short blasts close together, when the train is standing, is a signal that the train is about to be backed up. It is also the proper answer to a signal to the engineer to back up.

Four short blasts close together is a signal given when calling for signals from some one else that will govern the movement of your engine or train.

One long blast followed by two short ones should call the attention of trains of the same or inferior class to signals displayed on your engine for a following section. If this whistle signal is not answered by the trains whose rights are affected by the classification signals carried by you, it is your duty to be sure and get the notice to them at once, even if it requires a stop and a personal notice to the crew of such train.

Two long blasts followed by two short ones is the signal given when approaching public crossings at grade. This signal is required by law in a great many states, and should be properly given, and at the legal distance prescribed, in order that it may be a legal notice.

A succession of short blasts is an alarm for persons or cattle on the track, and calls the attention of trainmen to danger ahead.

**17. Torpedo Signals.**—Torpedo signals are audible signals made by the explosion of a torpedo placed on the rail. A torpedo produces a loud, sharp report, when a truck wheel runs over it, that attracts the attention of all hearing it. Torpedoes should not be placed where they will injure any one by their explosion; thus, they should be kept away from

passenger platforms and other localities where passers-by might be injured by fragments. The explosion of one torpedo is a signal to stop, the explosion of two—not more than 200 feet apart—is a signal to reduce speed and look out for a stop signal later. In case two torpedoes are put down and only one of them explodes, it gives the stop signal, instead of the proceed slowly signal; yet the train should stop at once, and a man be sent ahead, if necessary, or the train proceed very cautiously.

In placing torpedoes so that their explosion will indicate stop, it is customary on some roads to place two, one on each rail opposite each other, so that the reports will be simultaneous. For "proceed with caution," they are placed on the same rail about 200 feet apart.

18. **Air-Whistle or Bell-Cord Signals.**—Signals given by the air signal or by the bell cord operating the cab bell on the engine are used as follows:

Two sounds when the train is standing is a signal to start.

Two sounds when the train is moving is a signal to stop at once.

Three sounds when the train is standing is a signal to back up.

Three sounds when the train is running is a signal to stop at the next station.

Four sounds when the train is standing is a signal to apply or release air brakes.

Four sounds when the train is running is a signal to reduce speed.

Five sounds when the train is standing is a signal to call in flagmen.

Five sounds when the train is running is a signal to increase speed.

It will be noticed that one sound alone is not used for a signal, as it may be given accidentally, as by the train parting, or by some derangement of the signaling apparatus.

## TRAIN SIGNALS

**19. Engine Lights.**—The head-light will be displayed to the front of every train by night, but must be concealed when a train turns out to meet another and has stopped clear of the main track, or in standing to meet trains at the end of double tracks, or at junction points. You will notice that no particular class of train is specified in this rule, which makes it apply, therefore, to every train—even to a passenger train in to clear for a freight, or a superior train in to clear for an inferior train. It is customary to regard an open head-light, showing toward an approaching train, as a signal that the route of the approaching train is blocked. If the head-light is covered, the route is supposed to be clear. In case a head-light is obscured by cars ahead of it concealing it from the view of the approaching train, it is acting the part of safety to flag the approaching train in case its track is not clear. If two or more trains are taking the siding for an approaching train, it is a safe precaution for the leading engine to show an open head-light until all the trains are in to clear. Rule 17 does not in so many words specify this, but special rules do. In the absence of any special rules to govern the case of a disabled head-light that does not show, as provided by Rule 17, it should be the duty of the person in charge of the train to notify the superintendent that the head-light is disabled.

**20. Yard-Engine Lights.**—Yard engines will display a head-light to both front and rear by night. In case there is no head-light showing to the rear, two white lights must be displayed. The two white lights are to show that the engine is a yard engine, and hence that no markers are displayed; therefore, the rear of the engine itself, or the string of cars attached to it when at work, does not show that the entire train has passed, as is the case with main-line trains. Yard engines will not display markers.

**21. Markers.**—On each side of the rear of every train a green flag will be displayed, by day, as markers to indicate the rear of the train. By night, will be displayed a green

light to the front and side and a red light to the rear. When the train turns out to be passed by another and is clear of the main track, the red light must be changed for a green one so that green lights will then show to the front, side, and rear.

Ordinarily, the markers have three or more lenses of the proper color, combined in one lamp.

It is very important that these lamps be in good order and burn brightly, as the green light showing ahead is a signal to the engineer that the rear end is coming, the one toward the side is the marker for passing trains or station employes, while the red light serves to locate the rear end of the train for following trains, that they may not come in collision with it.

**22. Trains Running in Sections.**—When a regular train runs in sections, all the sections, except the last, will display two green flags by day or night, and in addition, two green lights by night in the places provided for that purpose on the front of the engine. These signals are usually called *classification signals*, as they denote that the following section has the same class or schedule rights as the train carrying the signal. The place provided for these signals is up next to the head-light or stack, whether the engine is running forwards or backwards, while markers are carried at the rear end. If a lone engine is running backwards, the markers will be carried on the pilot.

Extra trains carry two white flags by day and in addition two white lights by night, in the places provided for that purpose on the front of the engine.

While Rule 20 does not say in so many words that only regular trains can carry green signals for a following section, yet the definition of a regular train makes that clear, as it states that regular trains may consist of sections; it does not give extra trains that right.

**23. Double-Heading.**—If two or more engines are coupled to a train, only the leading engine will display the signals, as provided in Rules 20 and 21. The flags must not be taken down at night when the lamps are displayed,

but flags are to be used both day and night with the addition of the lamps between sunset and sunrise. During foggy weather, or where other conditions call for them, lamps should also be used in the daytime.

In case only one flag or lamp is displayed where two are required by Rules 19, 20, and 21, it will indicate the same as two; but in order that they may be visible to all concerned, no matter on which side of the engine they may be located, it is very important that two be displayed so that all can see them.

**24. Signal Given by Train Carrying Following-Section Signals.**—The signal to be given by the engineman carrying signals to call the attention of trains of the same or inferior class to signals displayed for a following section is one moderately long blast followed by two short ones. This should be carefully attended to, as it is a matter of the greatest importance that trains be notified of following sections. Enginemen of trains that may be notified by the whistle signal that signals are carried for following sections, should reply with the answering signal of two short blasts of the whistle.

**25. Engine Pushing Cars.**—When cars are pushed by an engine (except when shifting or making up trains in yards) a white light must be displayed on the front of the leading car at night. It is also customary to station a man on the leading car at the end farthest from the engine, either by day or by night, to keep a lookout and give signals if necessary. This precaution should always be observed, especial care being taken when cars are pushed over public crossings, in order that warning may be given if persons are on the track or the track is in any way obstructed. See Rule 102.

**26. Signaling From Cars to Engine.**—Each car on a passenger train must be connected with the engine by a communicating signal appliance. This may consist of a bell cord reaching from the rear end of the last car to the gong bell in the engine cab, or to an air-signal device. It should

be tested before starting out on a trip, to be sure that it is in working order. You will notice that Rule 16 does not state anything about one sound of the signal; therefore, if only one sound is given, it is a sign that something is wrong with the signal apparatus or that the train has parted. In the event of the signal apparatus being at fault, it may be that the trainmen are trying to give the proper signals and that the device does not work after the first pull. Notice should be taken at once of any signal that may be given, and attention directed to the other end of the train, in order to see if other signals are given.

27. **Protecting Workmen Under Engine, Etc.** Steps should be taken to protect persons that may be working under or about any car or engine, so as to insure its not being moved or even having anything else coupled on to it. For this purpose a blue flag by day and a blue light by night is displayed on one or both ends of any engine, car, or train it is thus desired to protect, and no car, engine, or train must be moved while so protected. When a blue flag or light is thus displayed, it must be removed only by the man that placed it there. Other cars must not be placed so as to hide or cover the view of the blue signal without first notifying the workmen, in order that they can set the blue signal where it is again visible. If a car thus protected is moved only a few inches, it may injure or kill the workman that relies on the protection of this signal.

Fixed signals are placed at railroad crossings, junctions, stations, and other points when required, and they are used in accordance with special instructions issued.

28. **Signals Imperfectly Displayed.**—It is one of the foundation rules for the use of signals that a signal imperfectly displayed, or the absence of a signal where one is usually shown, shall be regarded as a stop signal, and the fact must be reported as soon as possible to some responsible authority. If an imperfectly displayed signal were to be regarded as a clear signal, the train might get up so close that a stop could not be made at the proper place; also, if

the absence of a signal were regarded as a clear signal, it might cause the same trouble. Thus, the proper and safe plan is to at once reduce speed and be ready to stop. Also, the occurrence should be reported to the proper authority at once, so that following trains can be notified and measures taken to have the signal properly displayed or replaced.

**29. Stopping at Flag Stations.**—To stop trains at a flag station, a combined green and white signal is to be used. In case a train is to be stopped at any point not a flag station for that train, a red signal must be used. This would imply that a green and white signal will not stop a train, unless it is shown on the schedule that it is a flag station for that train.

When any signal is given to stop a train, it must, unless it is a fixed signal, be acknowledged by two short blasts of the engine whistle, as provided by Rule 14. This is important, especially when acknowledging signals of a flagman who is acting under Rule 99. If the conductor should happen to give a bell-cord or air-whistle signal at the same time, and the engineman answers, such answer may be mistaken by the flagman as an answer to his signal to stop; the flagman should bear this in mind and be sure to get the engineman's attention.

**30. Ringing Engine Bell.**—The engine bell must be rung whenever the engine is about to move, in order to give warning to any one under or about the engine or the cars attached to that engine. It must also be rung on approaching every public road crossing at grade, and continued until the crossing is passed. In many states this is required by law; the distance is usually 40 rods, in some cases 80 rods. The whistle must also be sounded at all whistling posts, some of which are for stations and railroad crossings, and others for highway crossings. Rule 14 requires that the whistle signal for highway crossings shall be two long blasts followed by two short blasts, with a short interval between each of the blasts; and for stations, junctions, and crossings of railroads at grade, a moderately long distinct blast. As a too frequent use of the whistle interferes with its effectiveness,

and as it is also prohibited by law in many cities and municipalities, its unnecessary use is prohibited by Rule 32; still, it must be used when required by the law or by the rules.

Watchmen at public crossings are not allowed to use red signals except to stop trains. The rule implies that a watchman should have two flags, one to signal trains ahead and one to stop them.

## CLASSIFICATION OF TRAINS

**31. How Classified.**—Regular trains are classified on the time-table with regard to their priority of right to the track. Their schedules of leaving and arriving times, and also their numbers, are arranged in the several classes, *first*, *second*, *third*, and so on, in regular order. Trains of the first class are superior to trains of the second and all succeeding classes; trains of the second class are superior to those of the third, etc. Extra trains are inferior to regular trains of whatever class. Therefore, first-class trains have the right of track over all trains of inferior class and extras; second-class trains have right of track over all inferior-class trains and extras; third-class trains have right of track over inferior trains and extras; and so on. Trains moving on single track in a certain direction, which is specified on the time-table, are superior to trains of the same class moving in the opposite direction. This does not refer to extras, as they are not represented on the time-table and have no rights but those conferred by train order. This right of track according to direction does not apply to double track.

**32. Train Losing Its Rights.**—When any regular train becomes 12 hours behind schedule time, it loses all rights, both those given it by train orders and by time-table, and can thereafter proceed only by special order. As this outlawed train loses its train-order rights, it follows that any meeting orders in its favor also die, and other trains so held can proceed against them the same as if they were annulled. See Rule 220.

## MOVEMENTS OF TRAINS

**33. Train Leaving Initial Station.**—A train must not leave its initial station on any division, or junction, or pass from double to single track, until it has ascertained whether all trains due, which are the same or of superior class, have arrived or left. At all such points it is customary to have a register, in which all trains that arrive or leave must register, giving the train number and the exact time. This is the duty of the person in charge of the train; it should be promptly attended to, as inferior trains cannot proceed until it is definitely known that there are no overdue trains that affect their rights. In some cases a special rule requires the engineman of the train to find out for himself, by examining the register personally, that he has a right to proceed. If this personal examination of the register is not required by the rules, the engineman should inquire of the conductor if all overdue trains have arrived.

In the case of a train of the same class going in the same direction from an initial station, or junction, as the overdue train, it can proceed on its own time-table rights and the overdue train will follow, being governed by Rule 91, which requires the overdue train to run 5 minutes behind the other except at meeting and passing points, where they can close up. This separation time varies on different roads using the Standard Code, and the student should inform himself as to the time limit used on the road in which he is interested. See Rules 84 and 93.

**34. Starting of Train.**—A train must not start until the proper signal is given. This means a signal from the proper person, as well as one given in the proper manner. The proper person to give a signal to start is the one in charge of the train, the conductor; as he is the only man that is sure to know that the train is ready to move, it is his duty to find this out. At some crowded stations, the matter of starting trains is in the hands of one person, who gives signals for all trains to leave, which prevents delays that

would otherwise hold all trains, as the time between trains may be very limited.

The signal should be given in the manner specified in the rules, so that there may be no chance of confusing it with other signals and so starting a train before it is ready to move.

**35. Inferior and Superior Trains.**—An inferior train must keep out of the way of a superior train. This is one of the most important rules connected with train operations, and for the safety of all, it must be lived up to literally. The superior train moves along relying on the inferior trains to do this, and the burden of its observance falls on the inferior trains only.

When there is a time limit of clearance imposed by the rules, in which the inferior train must clear the superior train, no part of the clearance time before the superior train is due can be used to get in off the main track. In case any train fails to clear the main track by the time required by rule, it must be protected, as provided in Rule 99, by having a flagman out a sufficient distance to insure full protection, and the flagman must be out at the proper distance before the moment arrives at which the clearance time begins.

One of the cardinal points in the safety of train movement is that a train which is not in to clear at, or before, the time specified, must be protected. At meeting points between trains of the same class, the inferior train must clear the main track before the leaving time of the superior train, and must pull into the siding when practicable. If necessary to back in, the train must first be protected as per Rule 99, unless otherwise provided. This rule applies to trains of the same class where one of them is superior by direction, and the one not having right to the main track should head in wherever possible, and thus leave the main track clear for the approaching superior train. If it is necessary to pull by the siding to be used for passing and back in, a flagman must first be sent out a sufficient distance to insure full protection. Special rules are very often made to suit certain locations, providing that the superior train, by direction, shall take the siding.

At meeting points on single track between trains of different classes, the inferior train must take the siding and clear the superior train at least 5 minutes, and must pull into the siding when practicable; in case it is necessary to back in, the train must first be protected as per Rule 99, unless otherwise provided. Rule 99 requires that the inferior-class train keep entirely off the main track for a space of 5 minutes before the superior train is due, and in case it cannot head into a siding it must be fully protected while pulling by and backing in.

An inferior train must keep at least 5 minutes off the time of a superior train running in the same direction, and the committee having in charge the revision of the Standard Code recommended that in case 5 minutes is not considered enough, it should be made 10 minutes when the superior train is following. They also recommend that at meeting points of trains of the same class, a clearance time of 5 minutes be allowed for greater safety.

It is understood that any statements as to meeting points between trains refer to single track only. When necessary to use one of the double tracks as a single track, it is done under the protection of a train order. Forms R and S provide for this.

**36. Approaching Meeting and Passing Points.** Trains on single track must stop at all schedule meeting or passing points if the train to be met or passed is of the same class, unless the switches are right and the track clear. This means that a train must approach such a point under full control and expecting to find the other train not clear of the main track. While the rule requires that the inferior train get in out of the way before the other train is due to pass the point, yet, there are so many conditions that may delay the inferior train after arrival at the schedule meeting or passing point, that for protection to both trains, it is necessary that the superior train be ready to stop, and this stop is made before reaching the switch that is to be used by the inferior train going on the siding. If the switches are all

right and the track clear, the superior train is not obliged to come to a full stop; but if the inferior train is not there, all subsequent sidings must be approached prepared to stop, as the expected train may be delayed there and not be in to clear.

**37. Trains Moving in Same Direction.**—Unless some form of block signal is used, trains moving in the same direction must keep at least 5 minutes apart, except in closing up at stations. This rule makes no mention of any class rights, but trains of inferior class must keep at least 5 minutes off the time of superior-class trains, by Rule 89, and in that way not delay them. It is not unusual to increase the clearance time to 10 minutes or more, as one of the dangers of train operations is that of a following train striking the rear end of the preceding one; this is the cause of a greater number of accidents than head-end collisions. When closing up at meeting or passing points, it is intended that following trains shall come in under control, expecting to find the main track occupied.

There is some difference of opinion as to the exact meaning of the term *under control*. Its use implies such a speed as will insure getting stopped before striking any obstruction. This, when following a train, may mean a certain speed, as there will be all the distance from which the obstruction is first visible to stop in; but if meeting an approaching train, there will be only half that distance, as the other train will use half of it to stop in, and therefore the speed should be less than in the first case. A good definition of under control is that you should be moving at such a rate of speed that the train can be stopped in one-half your range of vision. This will be a very slow speed on curves and down grade, and a much higher speed on straight track, with all the conditions favorable to see a long distance. A common error of all trainmen is underestimating the speed and momentum of their trains when moving under control.

**38. Train to Run on Time.**—A train must not arrive at a station in advance of its schedule arriving time. Rule 5

defines the schedule arriving time, as well as what is considered the leaving time.

A train must not leave a station in advance of its leaving time, one of the cardinal principles of the Standard Code being that a train has no existence until its schedule time has arrived, and, therefore, no train can run ahead of its schedule time, even by virtue of train orders.

A regular train that is delayed and thereby falls back on the time of another train of the same class does not thereby lose its time-table rights and will proceed on its own schedule. This, of course, implies that the delayed train will keep a lookout for the following train, in order to protect them against a rear-end collision. The train register will advise the following train that the other has preceded it. As the delayed train does not run on time, the following train must also keep a lookout for it. Rule D–93 states that on double track a regular train may pass and run ahead of a train of the same class or its sections. A section may pass and run ahead of another section of the same train, first exchanging orders, signals, and numbers with the section to be passed. An extra train may pass and run ahead of extra and _____ class trains or their sections. The blank space specifying the class of train that extras may pass and run ahead of is left to the various companies to fill out.

**39. Overtaking a Superior Train.**—A train that overtakes a superior train, or a train of the same class so disabled that it cannot proceed, will pass it, if practicable, and, if necessary, will assume the schedule and take the train orders of the disabled train, and proceed to the next open telegraph office and report to the proper officer. The disabled train will assume the schedule and take the train orders of the last train with which it has exchanged, and proceed to, and report from, the next open telegraph office. It is obvious from the wording of the above rule that it provides for one train passing another of the same or superior class at a non-telegraph station; because, if this were to happen at an open telegraph office, it could be at once arranged by train order,

and so no delay or difficulty occur to the train passing the disabled one. The qualifying words, if necessary, mean that if the train can proceed on its own rights and orders, it need not exchange orders with the disabled train, but may pass it and proceed to the next open telegraph office and report for orders. If the schedule and orders are exchanged, such action invests the disabled train with the rights and orders it has received in exchange for the ones it had, and if more than one exchange is needed with passing trains, this rule still holds good. When exchanges are thus made, the disabled train is less liable to become outlawed by getting over 12 hours late. As an exchange of train orders will confuse the engine numbers used as identifying marks in the train orders, any trains met on these orders should be fully informed as to the transfer of orders.

**40. Displaying Signals for Following Section.**—A train must not display signals for a following section, nor an extra train be run, without orders from some proper authority specified in the rules. This keeps in the hands of one responsible officer the power of starting trains not provided for by the time-table.

When signals displayed for a section are taken down at any point before that section arrives, the conductor will, if there is no other provision, arrange with the operator to notify all opposing trains of the same or inferior class leaving such point that the section for which the signals were displayed has not arrived. If there is no operator at the point, the conductor will arrange with the switch tender, or, in his absence, with a flagman left there for the purpose. A place is usually provided on each train register for registering the signal carried, which will give notice to all trains; for that reason, train registers should be carefully inspected, even if the train has been met at some other point. Although the rule does not say so explicitly, a written notice to the operator or switch tender is safer than a verbal notice of the signal carried, as there can then be no mistake in the train number. When the following section

arrives and reports, the operator, switch tender, or flagman's duty is finished.

As the carrying of signals for a following section has the effect of giving the following section the rights of both class and direction belonging to the leading section, it is very essential to the safety of all trains of the same or inferior class that all these rules be strictly lived up to. The signals do not affect trains superior by class and direction, so no provision is made for notifying them. Trains of the same or superior class getting in between the sections do not affect the rights of any of the sections, and opposing trains must see that they meet all the sections and also all regular trains that affect their rights, in order to work among sections carrying signals.

If a following section leaves the main track at a junction where there is no train register, operator, or switch tender, it is necessary, in order to avoid delay to opposing trains whose rights are affected, that a flagman be left at the junction to notify all concerned that the following section has arrived; otherwise, the opposing train would have no way of knowing this. This is a case not liable to happen very often.

**41. Running of Work Extras.**—Work extras will be assigned working limits, and they cannot go outside those limits without further orders. A work extra is different from any ordinary extra train in that it can move both ways within certain defined limits, and no other extra is allowed inside of those limits without first advising the work extra.

A work extra is required to let other extras pass it without train orders to that effect, which is not the case with ordinary extras. Work extras also use train orders directing them to run from one point to another, which do not allow them to move in both directions. A running order is not the same as a working order. On double track, it is provided by Rule D–97 that a work train must move with the current of traffic, unless its train orders direct otherwise.

**42. Approaching. Junctions, Crossings, Etc.** Trains must approach the end of double track, junctions,

railroad crossings at grade, and drawbridges prepared to stop if the switches and signals are not right and the track not clear. Where required by law, trains must stop. This provision is necessary, as at many of these points Rule 83 requires that it must be ascertained that there are no overdue trains whose non-arrival will affect your rights.

The laws of nearly all the states require a full stop at railroad crossings and drawbridges, unless an interlocking machine is in operation and the signals and switches are clear.

**43. Train Stopping or Being Delayed.**—When a train stops, or is delayed, under circumstances in which it may be run into by another train, it must be fully protected, both front and rear. The front end must be protected by an employe designated for that purpose. The rear end must be protected by the flagman who must immediately go back with stop signals a sufficient distance to insure full protection. This requires that he go back at once under all circumstances, as he has no means of knowing just how far back a following train is, or how great its speed and momentum may be. It is his duty to get back far enough so that his stop signal will be observed in time by the engineer of the following train, in order that he may have ample room to stop without running any risk of striking the first train, taking into consideration the grade and condition of rails. It is his (the flagman's) duty to take a full supply of signals suitable for the time of day and condition of the weather, and use them according to the rules formulated by each railroad for the use of stop signals. This is a matter of life and death to both employes and passengers, and no half-way measures are justifiable. When recalled by signals from his own train, he may return if he cannot hear or see a following train approaching, but in case a train is approaching, he must remain and get it stopped, before returning to his own train. Before he returns to his train, if no following train is in sight, he must place two torpedoes on the rail when the conditions require it. The usual method of placing torpedoes by the flagman before

he returns to his train and the train moves ahead again, is to put two on the right-hand rail, not more than 200 feet apart, so they will make two explosions, and notify the engineer that a flagman had been stationed there and recalled. The practice of railroads varies in this matter, each company making rules to suit its own conditions.

When a flagman goes back to protect the rear of his train, an employe designated for that purpose must at once take the flagman's place. On passenger trains, an employe is specially designated for this duty; on freight trains it is the duty of the next brakeman. This is in order to have another man ready to do the flagging in case the train proceeds before the regular flagman gets back to his post on the train.

**44. Train Parting While Running.**—If a train should part while in motion, trainmen must, if possible, prevent damage to the detached portion. This, of course, requires that the rear portion should be stopped before it can run into the front portion; therefore, it is necessary that the break-in-two shall be discovered as soon as possible after the train separates.

The signals prescribed by Rule 12 must be given by both trainmen and enginemen, the one that notices the break-in-two giving the signal at once, and the other answering the signal to signify that he understands. The front portion of the train must be kept in motion until the detached portion is stopped.

To detect a break-in-two when a train is being pulled is easiest done by seeing the gap between the two parts, but experience in this matter teaches trainmen and enginemen to look out for jerks and surges in the train at various points on the line. If the train has separated, it will handle different from a train that is all together. After it is certain that the rear portion has stopped, the front portion will go back to recover the detached portion, running with caution and following a flagman, who can see the rear portion far enough off, so that the front portion can be stopped soon

enough to avoid damage. This flagman is not intended as a protection against other trains following, but is to prevent the possibility of the two portions coming together and causing further damage. In many cases it will be necessary to go ahead to the next siding, leave the front portion there and then return with the engine for the rear portion, protecting yourself, if necessary, against any approaching trains that may be due at that siding before you can get back to it with the rear portion. This rule gives you an absolute right to return for the rear portion against any and all following trains, in order to get the rear portion out of the way as soon as possible, but on single track you must also be protected against superior trains due in an opposite direction. The detached portion must not be moved or passed around by any following engine or train, as that would risk a collision with the returning engine. After recovering the rear portion, you must look out for all trains in either direction, and be protected against them, if necessary, in order to move.

On double track, the front portion must give the train-parted signal to trains running in the opposite direction. A train receiving this signal from a train on the opposite track must stop and then proceed with caution until the detached portion of the train has been passed. When a train breaks down so as to obstruct the opposite track, trains on the opposite track must be stopped. In many cases a break-in-two is the result of a car getting off the track; therefore, all trains must look out for the rear part of a parted train.

**45. Precautions When Pushing Cars.**—When cars are being pushed by an engine (except when shifting or making up trains in yards), a flagman must take a conspicuous position on the front of the leading car and signal the engineman in case of need; this is to insure that the cars being pushed will not be moved against other cars or obstructions on the track, and to protect any persons crossing the track.

**46. Orders to Be in Writing.**—Messages or orders respecting the movement of trains or the condition of track or bridges must be in writing: (1) to make sure that they are understood; and (2) that a record of the instruction or order may be in the possession of the man in charge of the execution of the train movement, so that he can refer to it and not depend solely on his memory. So important has this question always been considered, that it is rulable, when getting orders, even from the highest authority, to insist that they be written, and not verbal orders alone. This, of course, refers to train orders or instructions regarding the movement of trains.

**47. Communications From Flagmen, Etc.**—Any communication that flagmen or watchmen may make is in the nature of information, and the exact location of any bad spot in the track or obstruction should be ascertained beyond a doubt before moving farther. This implies that statements made by a flagman or watchman on the ground to the engineman on a moving engine may not be properly understood and it is the duty of the engineman to stop, if necessary, to make sure.

**48. Care of Switches.**—Switches must be left in proper position after being used. Conductors are responsible for the position of the switches used by them and by their trainmen, except where switch tenders are stationed. Interlocking switches that are handled by a tower man are not in any way in the control of any of the trainmen, and they are not responsible for them; this rule refers to switches having separate connections thrown by hand. A switch must not be left open for a following train unless in charge of a trainman from following train; that is, a trainman of the preceding train must remain at the switch until relieved by a trainman of the following train; otherwise, the switch for the main track must be closed and locked.

Enginemen are expected to give attention to the proper closing of switches that they have just backed through with their trains, in order that they may be at once set for the main track, to avoid any danger to another train.

**49. Responsibility for Safety of Train.**—Both conductors and enginemen are responsible for the safety of their trains, and, under conditions not provided for by the rules, must take every precaution to insure such safety. In case of any failure on the part of one of them to observe the rules in regard to the rights of trains; to be in possession of proper train orders, or to take any of the precautions necessary for the safety of their train or others, this divided responsibility puts the other man in a position to look out for those duties, in which case he also is held responsible for the proper observance of all rules. The failure to conform to them may endanger the lives of all. Whenever any case of doubt or uncertainty arises, it is strictly prescribed that the safe side must be taken and no risks run; in many cases this will result in delay to the train, and a trainman or engineman that has a clear understanding of the rules and their operation will not be in doubt very often, while the man that has not thoroughly informed himself will be running serious risks, both to himself and others. These rules are as clear as can be made, unless special interpretations change their meaning on different divisions of the same system.

**50. Moving on the Proper Track.**—Rule D–151, which is used on double track only, specifies which of the two tracks must be used for the movement of trains in a certain direction; that is, with the current of traffic. Some companies use the right-hand track, others the left. In case it is necessary to use the other track special instructions are issued, in many cases in the form of train orders. In the case of joint tracks used by different companies, it is very essential that it is understood by all concerned which track to take.

**51. Crossing Over From One Track to the Other.** Rule D–152 makes provision for trains being protected when leaving one of the double tracks and crossing over to the other track. It distinctly specifies that when a train crosses over to, or obstructs the other track, unless otherwise provided for, it must first be protected, as prescribed by

Rule D–99, in both directions on that track. There are various means provided by the companies to protect trains crossing over, of which train orders or special orders in writing are common. The rules of each company govern in all cases, where they differ from the Standard Code.

**52. The Use of Track at a Passenger Platform.** Rule D–153 relates to the safety precaution adopted to protect passengers at a station. It provides that trains must use caution in passing a train receiving or discharging passengers at a station, and must not pass between it and the platform at which the passengers are being received or discharged. This is so obviously a safety precaution affecting the lives of passengers that it should be obeyed to the letter.

**53.** On October 28, 1903, there were added to the Code four rules governing the movement of trains with the current of traffic, on double track, by means of block signals. These rules, which are numbers D–251 to D–254, inclusive, provide that on portions of the road so specified on the time-table, trains will run with the current of traffic by block signals whose indications will supersede time-table superiority. This means that over the portions of track specified trains can proceed, when the block signals indicate proceed, without paying attention to other trains whose time-table rights would give them the right of track. This movement is with the current of track only, and is supervised by the superintendent or train despatcher, or whoever has charge of the movement of trains. In case a train has any work to do in the limits of any block, permission must first be obtained from the signalman at the last station at which there is a siding, before entering the block in which the work is to be done, and it is further provided that the signalman must obtain authority to give this permission from the officer responsible for directing train movements. This is to avoid having superior trains delayed by a train working in a block and making stops that will detain them. Without this permission they would likely be held at the

station where there was a siding. Except as provided in Rules D–251 to D–254, inclusive, all block-signal and train rules remain in force.

**54.** Rules D–261 to D–264, inclusive, provide for the movement of trains against the current of traffic on double track by means of block signals. These four rules were adopted April 27, 1904, and are an addition to the rules for moving with the current of traffic. These rules state that on portions of the road so specified on the time-table, trains will run against the current of traffic by block signals, whose indications will supersede time-table superiority, and will take the place of train orders.

When in operation, Rule D–261 in a manner supersedes Rule D–151, which specifies which track trains must take to follow the current of traffic. It also takes the place of train orders D–Form R or D–Form S, which would, without this rule, be necessary if a train was to move against the current of traffic. The movement of trains under this rule will be supervised by the superintendent or train despatcher, according as to who is responsible for directing the movement of trains, and he will issue the orders to the signalmen.

Rule D–263 provides that a train must not cross-over, except as provided in Rule D–261, without authority from the train despatcher or signalman. Except as affected by these rules, all block-signal and train rules remain in force. It is provided by the rules that roads operating trains against the current of traffic must provide proper signals to control the approach and movement of trains at the points where they cross-over to the opposite track.

Movements of trains against the current of traffic are also provided for by train orders.

# THE STANDARD CODE
OF THE
# AMERICAN RAILWAY ASSOCIATION

## TRAIN RULES FOR SINGLE TRACK

ADOPTED APRIL 12, 1899;
WITH AMENDMENTS AGREED TO APRIL 24, 1901, AND APRIL 23, 1902

(*Form of Order Putting Rules in Effect*)

The rules herein set forth govern the railroads operated by the ______________________ Company. They take effect ______________ superseding all previous rules and instructions inconsistent therewith.

Special instructions may be issued by proper authority.

(Name) ______________________________

(Title) ______________________________

### GENERAL NOTICE

To enter or remain in the service is an assurance of willingness to obey the rules.

Obedience to the rules is essential to the safety of passengers and employes, and to the protection of property.

The service demands the faithful, intelligent and courteous discharge of duty.

To obtain promotion capacity must be shown for greater responsibility.

Employes, in accepting employment, assume its risks.

## GENERAL RULES

A. Employes whose duties are prescribed by these rules must provide themselves with a copy.

B. Employes must be conversant with and obey the rules and special instructions. If in doubt as to their meaning they must apply to proper authority for an explanation.

C. Employes must pass the required examinations.

D. Persons employed in any service on trains are subject to the rules and special instructions.

E. Employes must render every assistance in their power in carrying out the rules and special instructions.

F. Any violation of the rules or special instructions must be reported.

G. The use of intoxicants by employes while on duty is prohibited. Their habitual use, or the frequenting of places where they are sold, is sufficient cause for dismissal.

H. The use of tobacco by employes when on duty in or about passenger stations, or on passenger cars, is prohibited.

J. Employes on duty must wear the prescribed badge and uniform and be neat in appearance.

K. Persons authorized to transact business at stations or on trains must be orderly and avoid annoyance to passengers.

L. In case of danger to the company's property employes must unite to protect it.

---

### DEFINITIONS

TRAIN.—An engine, or more than one engine coupled, with or without cars, displaying markers.

REGULAR TRAIN.—A train represented on the time-table. It may consist of Sections.

SECTION.—One of two or more trains running on the same schedule displaying signals or for which signals are displayed.

EXTRA TRAIN.—A train not represented on the time-table. It may be designated as—

Extra—for any extra train, except work extra;
Work extra—for work train extra.

SUPERIOR TRAIN.—A train having precedence over other trains.

A train may be made superior to another train by RIGHT, CLASS, or DIRECTION.

RIGHT is conferred by train order; CLASS and DIRECTION by time-table.

RIGHT is superior to CLASS or DIRECTION. DIRECTION is superior as between trains of the same class.

NOTE.—Superiority by direction is limited to single track.

TRAIN OF SUPERIOR RIGHT.—A train given precedence by train order.

TRAIN OF SUPERIOR CLASS.—A train given precedence by time-table.

TRAIN OF SUPERIOR DIRECTION.—A train given precedence in the direction specified in the time-table as between trains of the same class.

NOTE.—Superiority by direction is limited to single track.

TIME-TABLE.—The authority for the movement of regular trains subject to the rules. It contains the classified schedules of trains with special instructions relating thereto.

SCHEDULE.—That part of a time-table which prescribes the class, direction, number and movement of a regular train.

MAIN TRACK.—A principal track upon which trains are operated by time-table, train orders or by block signals.

SINGLE TRACK.—A main track upon which trains are operated in both directions.

DOUBLE TRACK.—Two main tracks, upon one of which the current of traffic is in a specified direction, and upon the other in the opposite direction.

CURRENT OF TRAFFIC.—The direction in which trains will move on a main track, under the rules.

STATION.—A place designated on the time-table by name, at which a train may stop for traffic; or to enter or leave the main track; or from which fixed signals are operated.

SIDING.—A track auxiliary to the main track for meeting or passing trains, limited to the distance between two adjoining telegraph stations.

FIXED SIGNAL.—A signal of fixed location indicating a condition affecting the movement of a train.

NOTE.—The definition of a "Fixed Signal" covers such signals as slow boards, stop boards, yard limits, switch, train order, block, interlocking, semaphore, disk, ball or other means for indicating stop, caution or proceed.

YARD.—A system of tracks within defined limits provided for the making up of trains, storing of cars and other purposes, over which movements not authorized by time-tables, or by train order, may be made, subject to prescribed signals and regulations.

YARD ENGINE.—An engine assigned to yard service and working within yard limits.

PILOT.—A person assigned to a train when the engineman or conductor, or both, are not fully acquainted with the physical characteristics, or running rules of the road, or portion of the road, over which the train is to be moved.

## TRAIN RULES FOR SINGLE TRACK

1 to 106

### STANDARD TIME

1. Standard Time obtained from______ observatory will be telegraphed to all points from designated offices at ______, ____ M. daily.

NOTE TO RULE 1.—In order to detect possible errors at junction points and to secure uniformity, the Committee recommends that the time be disseminated to all points at the same hour. The Committee considers it of great importance that the time be obtained from some observatory of recognized standing.

2. Watches that have been examined and certified to by a designated inspector must be used by conductors and enginemen. The certificate in prescribed form must be renewed and filed with ______ every ______.

(*Form of Certificate*)

CERTIFICATE OF WATCH INSPECTOR

This is to certify that on______________________ 19___ the watch of________________________________ employed as__________ ____________________on the____________________ R______ was examined by me. It is correct and reliable, and in my judgment will, with proper care, run within a variation of thirty seconds per week.

Name of maker________________________________________

Brand ______________________________________________

Number of movement____________________________________

Open or hunting case___________________________________

Metal of case________________________________________

Stem or key winding___________________________________

Signed,

____________________________________

*Inspector.*

Address______________________________________________

3. Watches of conductors and enginemen must be compared, before starting on each trip, with a clock designated as a standard clock. The time when watches are compared must be registered on a prescribed form.

NOTE TO RULE 3.—The conditions under which conductors and enginemen whose duties preclude access to a standard clock are required to obtain standard time, vary so much on different roads that the Committee recommends that each adopt such regulations to cover the case supplementary to this rule, as may best suit its own requirements.

---

## TIME-TABLES

4 (A). Each time-table, from the moment it takes effect, supersedes the preceding time-table.

A train of the preceding time-table thereupon loses both right and class, and can thereafter proceed only by train order.

No train of the new time-table shall run on any division until it is due to start from its initial station, on that division, after the time-table takes effect.

4 (B). Each time-table from the moment it takes effect, supersedes the preceding time-table. A train of the preceding time-table shall

retain its train orders and take the schedule of the train of the same number on the new time-table.

A train of the new time-table which has not the same number on the preceding time-table shall not run on any division until it is due to start from its initial station, on that division, after the time-table takes effect.

NOTE TO RULES 4 (A) AND 4 (B).—The Committee has recommended two forms of Rule 4, leaving it discretionary with each road to adopt either, as best suits its own requirements.

5. Not more than two times are given for a train at any station; where one is given, it is, unless otherwise indicated, the leaving time; where two, they are the arriving and the leaving time.

Unless otherwise indicated, the time applies to the switch where an inferior train enters the siding; where there is no siding it applies to the place from which fixed signals are operated; where there is neither siding nor fixed signal, it applies to the place where traffic is received or discharged.

Schedule meeting or passing points are indicated by figures in **full-faced type.**

Both the arriving and leaving time of a train are in full-faced type when both are meeting or passing times, or when one or more trains are to meet or pass it between those times.

When a train takes a siding, extending between two adjoining telegraph stations, to be passed by one or more trains, the time at each end of the siding will be shown in full-faced type.

Where there are one or more trains to meet or pass a train between two times, or more than one train to meet a train at any station, attention is called to it by ______.

NOTE TO RULE 5.—The Committee recommends that each company adopt such method as it may prefer in filling the blank.

6. The following signs when placed before the figures of the schedule indicate:

"s"—regular stop:

"f"—flag stop to receive or discharge passengers or freight:

"¶"—stop for meals:

"l"—leave:

"a"—arrive.

---

## SIGNAL RULES

7. Employes whose duties may require them to give signals, must provide themselves with the proper appliances, keep them in good order and ready for immediate use.

8. Flags of the prescribed color must be used by day, and lamps of the prescribed color by night.

9. Night signals are to be displayed from sunset to sunrise. When weather or other conditions obscure day signals, night signals must be used in addition.

## VISIBLE SIGNALS

10. **COLOR SIGNALS**

| Color | Indication |
|---|---|
| (*a*) Red. | Stop. |
| (*b*) ——— | Proceed, and for other uses prescribed by the Rules. |
| (*c*) ——— | Proceed with caution, and for other uses prescribed by the Rules. |
| (*d*) Green and white. | Flag stop. See Rule 28. |
| (*e*) Blue. | See Rule 26. |

NOTE TO RULE 10.—The Committee has omitted giving the colors of signals (*b*) and (*c*) in Rule 10, leaving it discretionary with each road to use such colors as it may prefer.

11. A fusee on or near the track burning red must not be passed until burned out. When burning green it is a caution signal.

12. **HAND, FLAG AND LAMP SIGNALS**

| Manner of Using | Indication |
|---|---|
| (*a*) Swung across the track.* | Stop. |
| (*b*) Raised and lowered vertically.† | Proceed. |
| (*c*) Swung vertically in a circle across the track, when the train is standing.‡ | Back. |
| (*d*) Swung vertically in a circle at arm's length across the track, when the train is running.§ | Train has parted. |
| (*e*) Swung horizontally in a circle, when the train is standing.¶ | Apply air brakes. |
| (*f*) Held at arm's length above the head, when train is standing.° | Release air brakes. |

13. Any object waved violently by any one on or near the track is a signal to stop.

* Illustrated by diagram on page 59.
† Illustrated by diagram on page 59.
‡ Illustrated by diagram on page 60.
§ Illustrated by diagram on page 60.
¶ Illustrated by diagram on page 61.
° Illustrated by diagram on page 61.

## AUDIBLE SIGNALS

### 14. ENGINE STEAM WHISTLE SIGNALS

NOTE.—The signals prescribed are illustrated by "o" for short sounds; "——" for longer sounds. The sound of the whistle should be distinct, with intensity and duration proportionate to the distance signal is to be conveyed.

| Sound | Indication |
|---|---|
| (*a*) o | Stop. Apply brakes. |
| (*b*) —— —— | Release brakes. |
| (*c*) —— o o o | Flagman go back and protect rear of train. |
| (*d*) —— —— —— —— | Flagman return from west or south. |
| (*e*) —— —— —— —— —— | Flagman return from east or north. |
| (*f*) —— —— —— | When running, train parted; to be repeated until answered by the signal prescribed by Rule 12 (*d*).* Answer to 12 (*d*).* |
| (*g*) o o | Answer to any signal not otherwise provided for. |
| (*h*) o o o | When train is standing, back. Answer to 12 (*c*)† and 16 (*c*). |
| (*j*) o o o o | Call for signals. |
| (*k*) —— o o | To call the attention of trains of the same or inferior class to signals displayed for a following section. |
| (*l*) —— —— o o | Approaching public crossings at grade. |
| (*m*) ———— | Approaching stations, junctions and railroad crossings at grade. |

A succession of short sounds of the whistle is an alarm for persons or cattle on the track, and calls the attention of trainmen to danger ahead.

15. The explosion of one torpedo is a signal to stop; the explosion of two not more than 200 feet apart is a signal to reduce speed, and look out for a stop signal.

* See diagram, page 60.
† See diagram, page 60.

16. **AIR-WHISTLE OR BELL-CORD SIGNALS**

| Sound | Indication |
|---|---|
| (*a*) Two. | When train is standing, start. |
| (*b*) Two. | When train is running, stop at once. |
| (*c*) Three. | When train is standing, back the train. |
| (*d*) Three. | When train is running, stop at next station. |
| (*e*) Four. | When train is standing, apply or release air brakes. |
| (*f*) Four. | When train is running, reduce speed. |
| (*g*) Five. | When train is standing, call in flagman. |
| (*h*) Five. | When train is running, increase speed. |

**TRAIN SIGNALS**

17. The head-light will be displayed to the front of every train by night, but must be concealed when a train turns out to meet another and has stopped clear of main track, or is standing to meet trains at the end of double track or at junctions.

18. Yard engines will display the head-light to the front and rear by night. When not provided with a head-light at the rear, two white lights must be displayed. Yard engines will not display markers.

19. The following signals will be displayed, one on each side of the rear of every train, as markers, to indicate the rear of the train: By day, a green flag, by night, a green light to the front and side and a red light to the rear, except when the train turns out to be passed by another and is clear of main track, when a green light must be displayed to the front, side and to rear.*

20. All sections of a train, except the last, will display two green flags and, in addition, two green lights by night, in the places provided for that purpose on the front of the engine.†

21. Extra trains will display two white flags and, in addition, two white lights by night, in the places provided for that purpose on the front of the engine.‡

22. When two or more engines are coupled to a train, the leading engine only shall display the signals as prescribed by Rules 20 and 21.

23. One flag or light displayed where in Rules 19, 20 and 21 two are prescribed will indicate the same as two; but the proper display of all train signals is required.

---

* Illustrated by diagrams of Train Signals, Nos. 3, 4, 7, 8, 9, 11, 12, 13, and 14.
† Illustrated by diagrams of Train Signals, Nos. 5, 6, 7, and 8.
‡ Illustrated by diagrams of Train Signals, Nos. 1, 2, 3, and 4.

24. When cars are pushed by an engine (except when shifting or making up trains in yards) a white light must be displayed on the front of the leading car by night.‡

25. Each car on a passenger train must be connected with the engine by a communicating signal appliance.

26. A blue flag by day and a blue light by night, displayed at one or both ends of an engine, car or train, indicates that workmen are under or about it. When thus protected it must not be coupled to or moved. Workmen will display the blue signals and the same workmen are alone authorized to remove them. Other cars must not be placed on the same track so as to intercept the view of the blue signals, without first notifying the workmen.

---

### USE OF SIGNALS

27. A signal imperfectly displayed, or the absence of a signal at a place where a signal is usually shown, must be regarded as a stop signal, and the fact reported to the ——.

28. The combined green and white signal is to be used to stop a train only at the flag stations indicated on the schedule of that train. When it is necessary to stop a train at a point that is not a flag station for that train, a red signal must be used.

29. When a signal (except a fixed signal) is given to stop a train, it must be acknowledged as prescribed by Rule 14 (*g*).

30. The engine-bell must be rung when an engine is about to move.

31. The engine-bell must be rung on approaching every public road crossing at grade, and until it is passed; and the whistle must be sounded at all whistling-posts.

32. The unnecessary use of either the whistle or the bell is prohibited. They will be used only as prescribed by rule or law, or to prevent accident.

33. Watchmen stationed at public road and street crossings must use red signals only when necessary to stop trains.

---

### CLASSIFICATION OF TRAINS

81. Trains of the first class are superior to those of the second; trains of the second class are superior to those of the third; and so on. Extra trains are inferior to regular trains.

---

‡ Illustrated by diagrams of Train Signals, Nos. 15 and 16.

All trains in the direction specified in the time-table are superior to trains of the same class in the opposite direction.

82. Regular trains twelve hours behind their schedule time lose both right and class, and can thereafter proceed only by train order.

---

## MOVEMENT OF TRAINS

83. A train must not leave its initial station on any division, or a junction, or pass from double to single track, until it has been ascertained whether all trains due, which are superior, or of the same class, have arrived or left.

84. A train leaving its initial station on each division, or leaving a junction, when a train of the same class in the same direction is overdue, will proceed on its schedule, and the overdue train will run as prescribed by Rule 91.

85. A train must not start until the proper signal is given.

86. An inferior train must keep out of the way of a superior train.

87. A train failing to clear the main track by the time required by rule, must be protected as prescribed by Rule 99.

88. At meeting points between trains of the same class the inferior train must clear the main track before the leaving time of the superior train, and must pull into siding when practicable. If necessary to back in, the train must first be protected, as prescribed by Rule 99, unless otherwise provided.

89. At meeting points between trains of different classes the inferior train must take the siding and clear the superior train at least five minutes, and must pull into the siding when practicable. If necessary to back in, the train must first be protected as prescribed by Rule 99, unless otherwise provided.

An inferior train must keep at least five minutes off the time of a superior train in the same direction.

NOTE TO RULES NOS. 88 AND 89.—The Committee recommends, that where greater clearance is necessary, Rule No. 88 should require a clearance of FIVE minutes, and Rule No. 89 of TEN minutes.

90. Trains must stop at schedule meeting or passing stations, if the train to be met or passed is of the same class, unless the switches are right and the track clear. Trains should stop clear of the switch used by the train to be met or passed in going on the siding.

When the expected train of the same class is not found at the schedule meeting or passing station, the superior train must approach

all sidings prepared to stop, until the expected train is met or passed.

91. Unless some form of block signals is used, trains in the same direction must keep at least five minutes apart, except in closing up at stations.

NOTE TO RULE 91.—The Committee recommends, that where greater clearance is necessary, Rule No. 91 should allow a clearance of TEN minutes or more.

92. A train must not arrive at a station in advance of its schedule arriving time.

A train must not leave a station in advance of its schedule leaving time.

93. A regular train which is delayed, and falls back on the time of another train of the same class, will proceed on its own schedule.

94. A train which overtakes a superior train or a train of the same class, so disabled that it cannot proceed will pass it, if practicable, and if necessary will assume the schedule and take the train orders of the disabled train, proceed to the next open telegraph office, and there report to the ______. The disabled train will assume the schedule and take the train orders of the last train with which it has exchanged, and will when able proceed to and report from the next open telegraph office.

95. A train must not display signals for a following section, nor an extra train be run without orders from the ______.

96. When signals displayed for a section are taken down at any point before that section arrives, the conductor will, if there be no other provision, arrange with the operator, or if there be no operator, with the switchtender, or in the absence of both, with a flagman left there for the purpose, to notify all opposing trains of the same or inferior class leaving such point that the section for which the signals were displayed has not arrived.

97. Work extras will be assigned working limits.

98. Trains must approach the end of double track, junctions, railroad crossings at grade, and drawbridges, prepared to stop, unless the switches and signals are right and the track is clear. Where required by law, trains must stop.

99. When a train stops or is delayed, under circumstances in which it may be overtaken by another train, the flagman must go back immediately with stop signals a sufficient distance to insure full protection. When recalled he may return to his train, first placing two torpedoes on the rail when the conditions require it.

The front of a train must be protected in the same way, when necessary, by the ______.

100. When the flagman goes back to protect the rear of his train, the ——— must, in the case of passenger trains, and the next brakeman in the case of other trains, take his place on the train.

101. If a train should part while in motion, trainmen must, if possible, prevent damage to the detached portions. The signals prescribed by Rules 12 (*d*) and 14 (*f*) must be given, and the front portion of the train kept in motion until the detached portion is stopped.

The front portion will then go back, to recover the detached portion, running with caution and following a flagman. The detached portion must not be moved or passed until the front portion comes back.

102. When cars are pushed by an engine (except when shifting and making up trains in yards) a flagman must take a conspicuous position on the front of the leading car and signal the engineman in case of need.

103. Messages or orders respecting the movement of trains or the condition of track or bridges must be in writing.

104. Switches must be left in proper position after having been used. Conductors are responsible for the position of the switches used by them and their trainmen, except where switchtenders are stationed.

A switch must not be left open for a following train unless in charge of a trainman of such train.

105. Both conductors and enginemen are responsible for the safety of their trains and, under conditions not provided for by the rules, must take every precaution for their protection.

106. In all cases of doubt or uncertainty the safe course must be taken and no risks run.

# RULES FOR DOUBLE TRACK

## STANDARD TIME

D–1. Standard Time obtained from ——— observatory will be telegraphed to all points from designated offices at ———, ——— M. daily.

NOTE TO RULE D–1.—In order to detect possible errors at junction points and to secure uniformity, the Committee recommends that the time be disseminated to all points at the same hour. The Committee considers it of great importance that the time be obtained from some observatory of recognized standing.

D–2. Watches that have been examined and certified to by a designated inspector must be used by conductors and enginemen. The certificate in prescribed form must be renewed and filed with ——— every ———.

(*Form of Certificate*)

CERTIFICATE OF WATCH INSPECTOR

This is to certify that on____________________ 19____

the watch of______________________________

employed as______________________________

on the______________________________R____
was examined by me. It is correct and reliable, and in my judgment will, with proper care, run within a variation of thirty seconds per week.

Name of maker______________________________

Brand______________________________

Number of movement______________________________

Open or hunting case______________________________

Metal of case______________________________

Stem or key winding______________________________

Signed,

______________________________

*Inspector.*

Address______________________________

D-3. Watches of conductors and enginemen must be compared, before starting on each trip, with a clock designated as a standard clock. The time when watches are compared must be registered on a prescribed form.

NOTE TO RULE D-3.—The conditions under which conductors and enginemen whose duties preclude access to a standard clock are required to obtain standard time, vary so much on different roads that the Committee recommends that each adopt such regulations to cover the case supplementary to this rule, as may best suit its own requirements.

## TIME-TABLES

D-4 (A). Each time-table, from the moment it takes effect, supersedes the preceding time-table.

A train of the preceding time-table thereupon loses both right and class, and can thereafter proceed only by train order.

No train of the new time-table shall run on any division until it is due to start from its initial station, on that division, after the time-table takes effect.

D–4 (B). Each time-table, from the moment it takes effect, supersedes the preceding time-table. A train of the preceding time-table shall retain its train orders and take the schedule of the train of the same number on the new time-table.

A train of the new time-table which has not the same number on the preceding time-table shall not run on any division until it is due to start from its initial station, on that division, after the time-table takes effect.

NOTE TO RULES D–4 (A) AND D–4 (B).—The Committee has recommended two forms of Rule D–4, leaving it discretionary with each road to adopt either, as best suits its own requirements.

D–5. Not more than two times are given for a train at any station; where one is given, it is unless otherwise indicated, the leaving time; where two, they are the arriving and the leaving time.

Unless otherwise indicated, the time applies to the switch where an inferior train enters the siding; where there is no siding it applies to the place from which fixed signals are operated; where there is neither siding nor fixed signal, it applies to the place where traffic is received or discharged.

Schedule passing stations are indicated by figures in **full-faced type.**

Both the arriving and leaving time of a train are in full-faced type when both are passing times, or when one or more trains are to pass it between those times.

When a train takes a siding, extending between two adjoining telegraph stations, to be passed by one or more trains, the time at each end of the siding will be shown in full-faced type.

When there are one or more trains to pass a train between two times, attention is called to it by ______.

NOTE TO RULE D–5.—The Committee recommends that each company adopt such method as it may prefer in filling the blank.

D–6. The following signs when placed before the figures of the schedule indicate:

"s"—regular stop:
"f"—flag stop to receive or discharge passengers or freight:
"¶"—stop for meals:
"l"—leave:
"a"—arrive.

## SIGNAL RULES

D–7. Employes whose duties may require them to give signals, must provide themselves with the proper appliances, keep them in good order and ready for immediate use.

D–8. Flags of the prescribed color must be used by day, and lamps of the prescribed color by night.

D–9. Night signals are to be displayed from sunset to sunrise. When weather or other conditions obscure day signals, night signals must be used in addition.

## VISIBLE SIGNALS

D–10. **COLOR SIGNALS**

| Color | Indication |
|---|---|
| (*a*) Red. | Stop. |
| (*b*) ——— | Proceed, and for other uses prescribed by the Rules. |
| (*c*) ——— | Proceed with caution, and for other uses prescribed by the Rules. |
| (*d*) Green and white. | Flag stop. See Rule D–28. |
| (*e*) Blue. | See Rule D–26. |

NOTE TO RULE D–10.—The Committee has omitted giving the colors of signals (*b*) and (*c*) in Rule D–10, leaving it discretionary with each road to use such colors as it may prefer.

D–11. A fusee on or near the track burning red must not be passed until burned out. When burning green it is a caution signal.

D–12. **HAND, FLAG AND LAMP SIGNALS**

| Manner of Using | Indication |
|---|---|
| (*a*) Swung across the track.* | Stop. |
| (*b*) Raised and lowered vertically.† | Proceed. |
| (*c*) Swung vertically in a circle across the track, when the train is standing.‡ | Back |
| (*d*) Swung vertically in a circle at arm's length across the track, when the train is running.§ | Train has parted. |
| (*e*) Swung horizontally in a circle, when the train is standing.¶ | Apply air brakes. |
| (*f*) Held at arm's length above the head, when train is standing.° | Release air brakes. |

D–13. Any object waved violently by any one on or near the track is a signal to stop.

*Illustrated by diagram on page 59.
†Illustrated by diagram on page 59.
‡Illustrated by diagram on page 60.
§Illustrated by diagram on page 60.
¶Illustrated by diagram on page 61.
°Illustrated by diagram on page 61.

## AUDIBLE SIGNALS

D–14. **ENGINE STEAM WHISTLE SIGNALS**

Note.—The signals prescribed are illustrated by "o" for short sounds; "——" for longer sounds. The sound of the whistle should be distinct, with intensity and duration proportionate to the distance signal is to be conveyed.

| Sound | Indication |
|---|---|
| (*a*) o | Stop. Apply brakes. |
| (*b*) —— —— | Release brakes. |
| (*c*) —— o o o | Flagman go back and protect rear of train. |
| (*d*) —— —— —— —— | Flagman return from west or south. |
| (*e*) —— —— —— —— —— | Flagman return from east or north. |
| (*f*) —— —— —— | When running, train parted; to be repeated until answered by the signal prescribed by Rule D–12 (*d*).* Answer to D–12 (*d*).* |
| (*g*) o o | Answer to any signal not otherwise provided for. |
| (*h*) o o o | When train is standing back. Answer to D–12 (*c*)† and D–16 (*c*). |
| (*j*) o o o o | Call for signals. |
| (*k*) —— o o | To call the attention of trains of the same or inferior class to signals displayed for a following section. |
| (*l*) —— —— o o | Approaching public crossings at grade. |
| (*m*) ———— | Approaching stations, junctions and railroad crossings at grade. |

A succession of short sounds of the whistle is an alarm for persons or cattle on the track, and calls the attention of trainmen to danger ahead.

D–15. The explosion of one torpedo is a signal to stop; the explosion of two not more than 200 feet apart is a signal to reduce speed, and look out for a stop signal.

*See diagram, page 60.
†See diagram, page 60.

D-16. **AIR-WHISTLE OR BELL-CORD SIGNALS**

| Sound | Indication |
|---|---|
| (*a*) Two. | When train is standing, start. |
| (*b*) Two. | When train is running, stop at once. |
| (*c*) Three. | When train is standing, back the train. |
| (*d*) Three. | When train is running, stop at next station. |
| (*e*) Four. | When train is standing, apply or release air brakes. |
| (*f*) Four. | When train is running, reduce speed. |
| (*g*) Five. | When train is standing, call in flagman. |
| (*h*) Five. | When train is running, increase speed. |

### TRAIN SIGNALS

D-17. The head-light will be displayed to the front of every train by night, but must be concealed when a train is standing to meet trains at the end of double track or at junctions.

D-18. Yard engines will display the head-light to the front and rear by night. When not provided with a head-light at the rear, two white lights must be displayed. Yard engines will not display markers.

D-19. The following signals will be displayed, one on each side of the rear of every train, as markers, to indicate the rear of the train: By day, a green flag. By night, a green light to the front and side and a red light to the rear, except when the train turns out to be passed by another and is clear of main track, when a green light must be displayed to the front, side and to rear.*

D-20. All sections of a train, except the last, will display two green flags and, in addition, two green lights by night, in the places provided for that purpose on the front of the engine.†

D-21. Extra trains will display two white flags and, in addition, two white lights by night, in the places provided for that purpose on the front of the engine.‡

D-22. When two or more engines are coupled to a train, the leading engine only shall display the signals as prescribed by Rules D-20 and D-21.

D-23. One flag or light displayed where in Rules D-19, D-20 and D-21 two are prescribed will indicate the same as two; but the proper display of all train signals is required.

D-24. When cars are pushed by an engine (except when shifting or making up trains in yards) a white light must be displayed on the front of the leading car by night.§

*Illustrated by diagrams of Train Signals, Nos. 3, 4, 7, 8, 9, 11, 12, 13, and 14.
†Illustrated by diagrams of Train Signals, Nos. 5, 6, 7, and 8.
‡Illustrated by diagrams of Train Signals, Nos. 1, 2, 3, and 4.
§Illustrated by diagrams of Train Signals, No. 9.

D–25. Each car on a passenger train must be connected with the engine by a communicating signal appliance.

D–26. A blue flag by day and a blue light by night, displayed at one or both ends of an engine, car or train, indicates that workmen are under or about it. When thus protected it must not be coupled to or moved. Workmen will display the blue signals and the same workmen are alone authorized to remove them. Other cars must not be placed on the same track so as to intercept the view of the blue signals, without first notifying the workmen.

## USE OF SIGNALS

D–27. A signal imperfectly displayed, or the absence of a signal at a place where a signal is usually shown, must be regarded as a stop signal, and the fact reported to the ——.

D–28. The combined green and white signal is to be used to stop a train only at the flag stations indicated on the schedule of that train. When it is necessary to stop a train at a point that is not a flag station for that train, a red signal must be used.

D–29. When a signal (except a fixed signal) is given to stop a train, it must be acknowledged as prescribed by Rule D–14 (*g*).

D–30. The engine-bell must be rung when an engine is about to move.

D–31. The engine-bell must be rung on approaching every public road crossing at grade, and until it is passed; and the whistle must be sounded at all whistling-posts.

D–32. The unnecessary use of either the whistle or the bell is prohibited. They will be used only as prescribed by rule or law, or to prevent accident.

D–33. Watchmen stationed at public road and street crossings must use red signals only when necessary to stop trains.

## CLASSIFICATION OF TRAINS

D–81. Trains of the first class are superior to those of the second; trains of the second class are superior to those of the third; and so on. Extra trains are inferior to regular trains.

D–82. Regular trains twelve hours behind their schedule time lose both right and class, and can thereafter proceed only by train order.

## MOVEMENT OF TRAINS

D-83. A train must not leave its initial station on any division, or a junction, until it has been ascertained whether all superior trains due have left.

D–84. A train leaving its initial station on each division, or leaving a junction, when a train of the same class is overdue, will proceed

on its schedule, and the overdue train will run as prescribed by Rule D–91.

D–85. A train must not start until the proper signal is given.

D–86. An inferior train must keep out of the way of a superior train, and clear its time at least five minutes.

NOTE TO RULE D–86.—The Committee recommends, that where greater clearance is necessary, Rule D–86 should require a clearance of TEN minutes.

D–87. A train failing to clear the main track by the time required by rule, must be protected as prescribed by Rule D–99.

88. Omitted. (Not applicable to Double Track.)

89. Omitted. (Included in Rule D–86.)

90. Omitted. (Not applicable to Double Track.)

D–91. Unless some form of block signals is used, trains must keep at least five minutes apart, except when closing up at stations.

NOTE TO RULE D–91.—The Committee recommends; that where greater clearance is necessary, Rule D–91 should allow a clearance of TEN minutes or more.

D–92. A train must not arrive at a station in advance of its schedule arriving time.

A train must not leave a station in advance of its schedule leaving time.

D–93. A regular train which is delayed, and falls back on the time of another train of the same class, will proceed on its own schedule.

A regular train may pass and run ahead of a train of the same class or its sections.

A section may pass and run ahead of another section of the same train first exchanging orders, signals and numbers with the section to be passed.

An extra train may pass and run ahead of extra and ______ class trains or their sections.

D–94. A train which overtakes a superior train, so disabled that it cannot proceed will pass it, if practicable, and if necessary will assume the schedule and take the train orders of the disabled train, proceed to the next open telegraph office, and there report to the ______. The disabled train will assume the schedule and take the train orders of the last train with which it has exchanged and will, when able, proceed to and report from the next open telegraph office.

D–95. A train must not display signals for a following section, except as prescribed by Rule D–93, nor an extra train be run, without orders from the ______.

96. Omitted. (Not applicable to Double Track.)

D–97. Work extras will be assigned working limits. Within these limits such trains must move with the current of traffic unless train orders otherwise direct.

D–98. Trains must approach the end of double track, junctions, railroad crossings at grade, and drawbridges, prepared to stop, unless

the switches and signals are right and the track is clear. Where required by law, trains must stop.

D–99. When a train stops or is delayed, under circumstances in which it may be overtaken by another train, the flagman must go back immediately with stop signals a sufficient distance to insure full protection. When recalled he may return to his train, first placing two torpedoes on the rail when the conditions require it.

The front of a train must be protected in the same way, when necessary, by the ——.

D–100. When the flagman goes back to protect the rear of his train, the —— must, in the case of passenger trains, and the next brakeman in the case of other trains, take his place on the train.

D–101. If a train should part while in motion, trainmen must, if possible, prevent damage to the detached portions. The signals prescribed by Rules D–12 (*d*) and D–14 (*f*) must be given, and the front portion of the train kept in motion until the detached portion is stopped.

The front portion will then go back, to recover the detached portion, running with caution and following a flagman. The detached portion must not be moved or passed until the front portion comes back.

The front portion must give the train-parted signal to trains running in the opposite direction. A train receiving this signal from a train on the opposite track must stop and then proceed with caution until the detached portion of the train has been passed. When a train breaks down so it may obstruct the opposite track, trains on the opposite track must be stopped.

D–102. When cars are pushed by an engine (except when shifting and making up trains in yards) a flagman must take a conspicuous position on the front of the leading car and signal the engineman in case of need.

D–103. Messages or orders respecting the movement of trains or the condition of track or bridges must be in writing.

D–104. Switches must be left in proper position after having been used. Conductors are responsible for the position of the switches used by them and their trainmen, except where switchtenders are stationed.

A switch must not be left open for a following train unless in charge of a trainman of such train.

D–105. Both conductors and enginemen are responsible for the safety of their trains and, under conditions not provided for by the rules, must take every precaution for their protection.

D–106. In all cases of doubt or uncertainty the safe course must be taken and no risks run.

D–151. Trains must keep to the ——, unless otherwise provided.

D–152. When a train crosses over to, or obstructs the other track, unless otherwise provided it must first be protected as prescribed by Rule D–99 in both directions on that track.

D–153. Trains must use caution in passing a train receiving or discharging passengers at a station, and must not pass between it and the platform at which the passengers are being received or discharged.

D–251. On portions of the road so specified on the time-table, trains will run with the current of traffic by block signals whose indications will supersede time-table superiority.

D–252. The movement of trains will be supervised by the ______* who will issue instructions to signalmen when required.

D–253. A train having work to do which may detain it more than ___ minutes, must obtain permission from the signalman at the last station at which there is a siding before entering the block in which work is to be done. The signalman must obtain authority to give this permission from the ______*.

D–254. Except as affected by these rules, all Block Signals and Train Rules remain in force.

NOTE.—Roads operating under these Rules D–261 to D–264, inclusive, must provide proper signals to control the approach and movement of trains.

D–261. On portions of the road so specified on the time-table, trains will run against the current of traffic by block signals, whose indications will supersede time-table superiority and will take the place of train orders.

D–262. The movement of trains will be supervised by the ______* who will issue instructions to signalmen.

D–263. A train must not cross over, except as provided in Rule D–261, without authority from the ______†.

D–264. Except as affected by these Rules, all Block Signals and Train Rules remain in force.

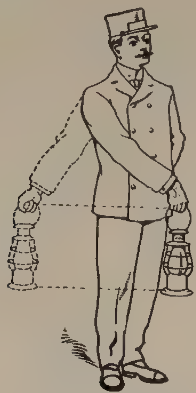
---

*Superintendent or Train Despatcher.
†Train Despatcher or Signalman.

# DIAGRAMS OF HAND, FLAG AND LAMP SIGNALS

ADOPTED APRIL 24, 1901

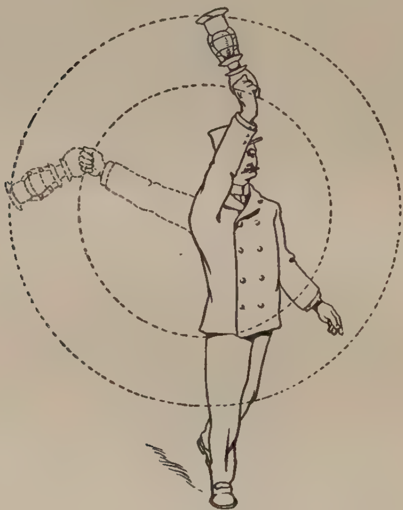
NOTE.—The hand, or a flag, moved the same as the lamp, as illustrated in the following diagrams, gives the same indication.



STOP—Swung across the track.
See Rules 12 (*a*) and D-12 (*a*).

PROCEED—Raised and lowered vertically.
See Rules 12 (*b*) and D-12 (*b*).

BACK—Swung vertically in a circle across the track.
See Rules 12 (*c*) and 14 (*h*) and D-12 (*c*) and D-14 (*h*).



TRAIN HAS PARTED—Swung vertically in a circle at arm's length across the track.
See Rules 12 (*d*) and 14 (*f*) and D-12 (*d*) and D-14 (*f*).

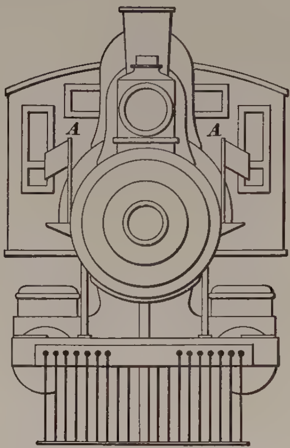
APPLY AIR BRAKES—Swung horizontally in a circle.
See Rules 12 (*e*) and D-12 (*e*).

RELEASE AIR BRAKES—Held at arm's length above the head.
See Rules 12 (*f*) and D-12 (*f*).

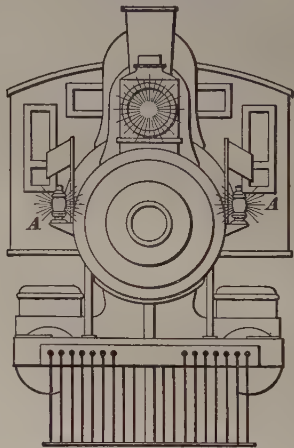
# DIAGRAMS O

ADOPTE

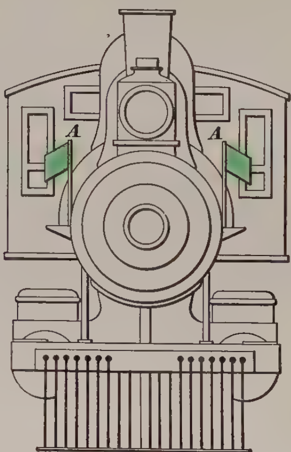
NOTES.—The diagrams are intended to illustrate the general locati
Combination lamps with four illuminated colored faces a



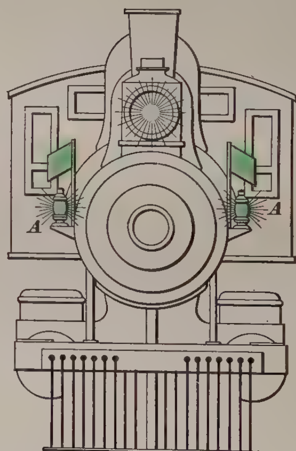

1. Engine Running Forward by Day as an Extra Train.—White flags at *A A*. See Rules 21 and D-21.




2. Engine Running Forward by Night as an Extra Train.—White lights and white flags at *A A*. See Rules 21 and D-21.




5. Engine Running Forward by Day Displaying Signals for a Following Section.—Green flags at *A A*. See Rules 20 and D-20.

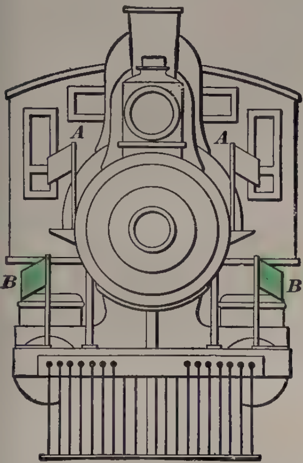



6. Engine Running Forward at Night Displaying Signals for a Following Section.—Green lights and green flags at *A A*. See Rules 20 and D-20.

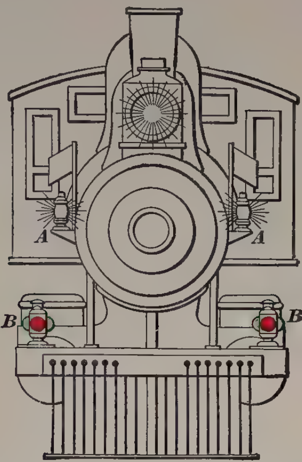
ꓤAIN SIGNALS

IL 24, 1901

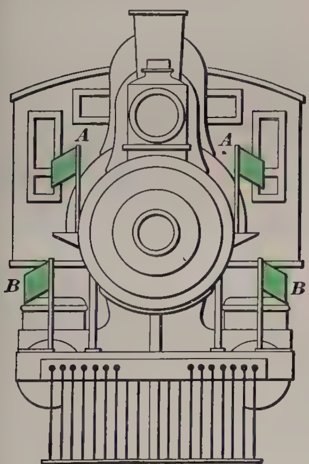
e train signals, not the exact manner in which they are to be attached.
sented in the diagrams.



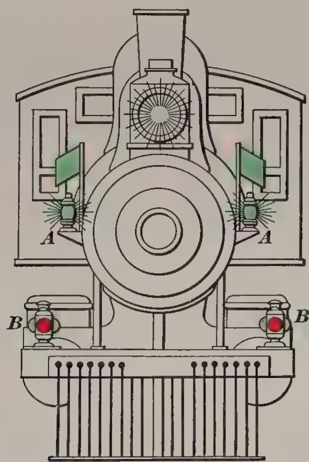

Engine Running Backward by Day as an Extra Train, Without Cars or at the Rear of a Train Pushing Cars.—White flags at *A A*. See Rules 21 and D-21. Green flags at *B B*, as markers. See Rules 19 and D-19.




4. Engine Running Backward by Night as an Extra Train, Without Cars or at the Rear of a Train Pushing Cars.—White lights and white flags at *A A*. See Rules 21 and D-21. Lights at *B B*, as markers, showing green at side and in direction engine is moving and red in opposite direction. See Rules 19 and D-21.

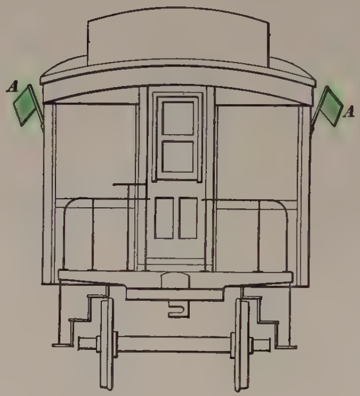



7. Engine Running Backward by Day, Without Cars or at the Rear of a Train Pushing Cars, and Displaying Signals for a Following Section.—Green flags at *A A*. See Rules 20 and D-20. Green flags at *B B*, as markers. See Rules 19 and D-19.

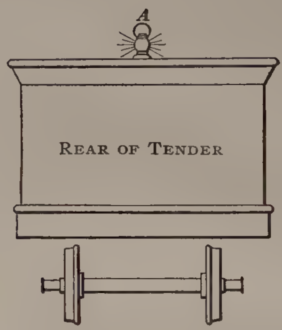



8. Engine Running Backward by Night, Without Cars or at the Rear of a Train Pushing Cars, and Displaying Signals for a Following Section.—Green lights and green flags at *A A*. See Rules 20 and D-20. Lights at *B B*, as markers showing green at side and in direction engine is moving and red in opposite direction. See Rules 19 and D-19.

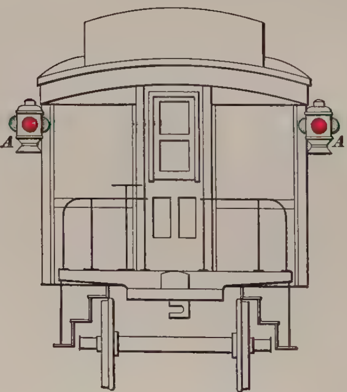
# DIAGRAMS OF



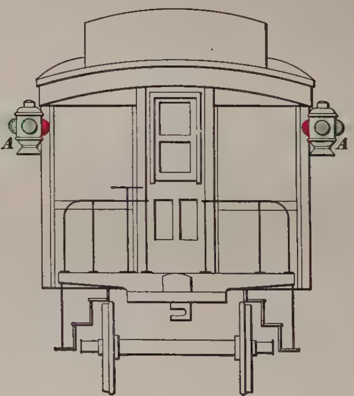

9. REAR OF TRAIN BY DAY.—Green flags at *A A*, as markers. See Rules 19 and D-19.




10. ENGINE RUNNING BACKWARD BY NIGHT, WITHOUT CARS OR AT THE FRONT OF A TRAIN PULLING CARS. White light at *A*.

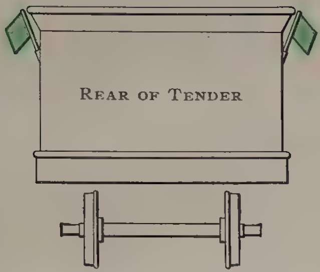



11. REAR OF TRAIN BY NIGHT WHILE RUNNING.—Lights at *A A*, as markers, showing green toward engine and side and red to rear. See Rules 19 and D-19.

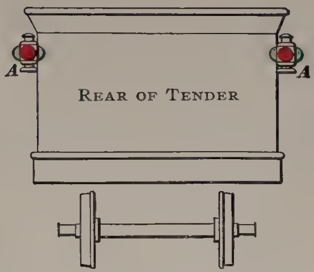



12. REAR OF TRAIN BY NIGHT WHEN ON SIDING TO BE PASSED BY ANOTHER TRAIN.—Lights at *A A*, as markers, showing green toward engine, side and to rear. See Rules 19 and D-19.

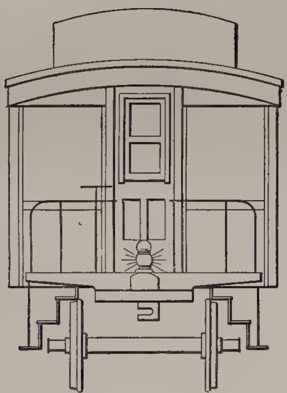
# RAIN SIGNALS



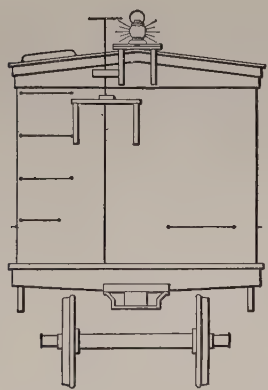

**13.** ENGINE RUNNING FORWARD BY DAY, WITHOUT CARS OR AT THE REAR OF A TRAIN PUSHING CARS.—Green flags, as markers. See Rules 19 and D-19.




**14.** ENGINE RUNNING FORWARD BY NIGHT, WITHOUT CARS OR AT THE REAR OF A TRAIN PUSHING CARS.—Lights at *A A*, as markers, showing green to the front and side and red to rear. See Rules 19 and D-19.



**15.** PASSENGER CARS BEING PUSHED BY AN ENGINE BY NIGHT.—White light on front of leading car. See Rules 24 and D-24.



**16.** FREIGHT CARS BEING PUSHED BY AN ENGINE BY NIGHT.—White light on front of leading car. See Rules 24 and D-24.

# TRAIN RULES

(PART 2)

## TRAIN ORDERS

**1. General Considerations.**—In the movement of trains by **train order,** much depends on those who are to execute them. The rules and forms of train orders are in a measure merely guides to action, depending on the judgment, care, and watchfulness of those concerned in their execution. Safety is the first consideration, and to this all else should be subordinate. To insure safety, it is necessary that every person interested in the movement of trains by train orders should have a clear understanding of their meaning, and that the various forms of orders prescribed by the rules be thoroughly understood. Promptness and despatch, though secondary, are of great importance in the successful movement of trains, hence the importance of trainmen and enginemen being prompt in responding to and complying with train orders. The train despatcher, in the issuing of orders, is often obliged to govern his action by information received from the conductor; therefore, the latter should make special effort to impart all the information that he can in regard to the work that he has to do at various stations, etc. Trainmen can often save time to their own train, as well as to others, by giving such information to the despatcher. Information of this kind will enable him to anticipate movements and have the necessary orders ready for trains when they are ready to act on them.

**2. Carrying Out Orders.**—Train orders should be plain and explicit and as short as it is possible to make them and

yet embody the necessary information. The conductors and enginemen receiving them should insist on their being plainly written in accordance with the rules, which admit of no alteration, interlineation, or erasures, and should fully understand them before proceeding to act on them. The conductor should read the order aloud to the operator, and the engineman to the conductor. This is preferable to the operator reading it to the conductor and the conductor reading, in turn, to the engineman, since any mistake that the operator might make in reading would likely be made by the conductor in reading to the engineman, through his repeating it from memory rather than reading it from the copy in his possession. Errors in the carrying out of train orders have occurred through their being treated in this manner, and it is therefore deemed better practice to require the person receiving a train order to read it aloud to the person from whom it is received. As a measure of safety, conductors should show train orders to their brakemen, and enginemen to their firemen, and each should see that the orders are understood. This is advisable for two reasons: the brakemen and firemen should know what trains are to be met and passed, and should also be on the lookout to see that the provisions of the orders on which their train may be running are complied with. The showing of train orders to brakemen and firemen is required by the rules of some roads, and these employes are held to a certain degree of responsibility in seeing that they are complied with.

---

## RULES FOR MOVEMENT BY TRAIN ORDERS

**3. Use of Train Orders.**—Movements not provided for by time-table will be regulated by train orders issued by authority and over the signature of the proper officer, who is usually the superintendent. Such orders must not contain any information or instructions that are not essential to such movements. They must be on the prescribed forms when applicable, and must be brief and clear and without erasure, alteration, or interlineation. Rule 201 is very clear about train orders. Only one statement is qualified in any

manner, which is, that the orders must be in the prescribed forms when applicable. This qualification allows the use of orders not in the prescribed standard forms when the standard forms do not apply to the conditions covered by the order.

**4. Nature of Train Orders.**—Train orders are usually issued according to a form provided especially for that purpose. Several copies of these orders are made at one writing by the use of a carbon sheet between the separate leaves; in this manner, each order is an exact duplicate of the other. If they are not brief and clear, there is danger of misunderstanding from a multiplicity of words. If they are not restricted to the prescribed forms, they are likely to be misunderstood, in which event they may be executed in a manner not intended by the person that composed the order; this provision is violated more often than is really necessary. In regard to erasures, alterations, or interlineations, they introduce an element of danger, and it is not considered safe to accept an order with these defects.

**5. Preparation of Train Orders.**—Each train order must be given in the same words to all persons or trains addressed, the arrangement of the duplicate sheets of tissue paper providing for this when the operator is copying the order as sent by the despatcher. Rule 209 further provides for this work; the purpose of this rule is to make sure that all persons that are to carry out the orders will get exactly similar orders, so as to understand just what has to be done. This feature of the Standard Code is one of its strongest safety precautions, since when all orders are exactly in the same words, the wrong meeting places cannot be put in and make what is sometimes called a *lap order* in the case of trains meeting on single track; it also notifies each train just what the others are expected to do. Train orders are numbered consecutively each day, usually beginning with No. 1, and the time of changing the numbers is at midnight. Each order is intended to have a number of its own, in order to identify it, as well as to show which order last took effect. This number (of the order) does not

depend on the number of the train but on the number of the last order previous; for instance, at midnight the numbers run out and the new series begins with the first order issued after that time—usually No. 1.

**6. Issuing of Train Orders.**—Train orders must be addressed to those who are to execute them, naming the place at which each is to receive his copy. Those for a train must be addressed to the conductor and engineman, and also to any one that acts as its pilot; as the pilot is responsible for the movement of the train, the copy is usually issued to him first, and, on his approval, the conductor signs for it. In some cases, the pilot alone signs for train orders. A copy for each person addressed must be supplied by the operator, so that the number of persons addressed governs in a manner the number of copies to be issued. Rule 202 provides that the body of the train order, which states the movements, should be the same for all trains receiving it. Rule 204 relates to the address at the top of the order, which is different for each train; the place named in the address is where they are to sign for it. A custom that is not directly prescribed by the Standard Code is to issue copies of train orders to all the engineers when more than one engine is coupled to a train; this matter is provided for in the address.

**7. Filling Out of Orders.**—Persons receiving train orders should see that they are properly filled out in every detail before accepting them. An order is not valid unless it bears: (1) a date, (2) a number, (3) the proper address of the person or train that is to act on it, (4) the name of station at which it is received, (5) the time the X response is given (if this form is used), (6) the time repeated or O K given, (7) the initials of the officer over whose name the order is issued, (8) the word complete, (9) the time made complete, and (10) the signature of the operator, in the space provided on the order. The omission of any one of these requirements invalidates the order, and if such order were accepted, the conductor would have to return to the

telegraph office to have the omission supplied, thereby losing valuable time.

**8. Keeping Record of Orders Issued.**—Each train order must be written in full in a book provided for the purpose at the office of the person issuing the order, and with it recorded: (1) the names of those that have signed for the order; (2) the time and the signals, which show when and from what offices the order was repeated; (3) the responses transmitted; and (4) the train despatcher's initials. These records must be made at the time and never subsequently from memory or memoranda. This injunction refers to the method of keeping the records in the office of the person that is responsible for issuing the orders.

Rule 216 makes provision for the train orders that are issued by the despatcher personally to those that are to execute them.

**9. Wording of Orders.**—Regular trains will be designated in train orders by their numbers, as No. 10; when running in sections, the sections are designated as 1st, 2d, or 3d No. 10, adding engine numbers, if desired. Extra trains will be designated by engine numbers, as Extra 798, with the direction when necessary, as East or West; other numbers and the time will be stated in figures only. It is still customary on many roads when a number is given in words, to follow the word with the same number in figures, as a precaution to avoid mistakes in reading the numbers.

**10. Transmitting the Orders.**—To transmit a train order, the signal "31," or "19," as the case may be, must be given to each office addressed, the number of copies being stated if more or less than three; thus, "31 copy 5," or "19 copy 2." Where Forms 31 and 19 are not both in use, the signal may be omitted. This is a notice to the operator of the form of order to be used and the number of copies he should make at the same time. As three is the usual number made (one for the conductor, one for the engineman, and one to be kept by the operator), when this number is required, it is not necessary to state it in the notice from

the despatcher to the operator, thus saving the telegraphing of a word.

A train order that is to be sent to two or more offices must be transmitted simultaneously to as many of them as practicable; this not only saves time and the use of the wire, but it is also an element of safety, as all the operators get the same order. The several addresses must be in the order of superiority of trains, each office taking its proper address and writing it in the proper place at the top of the order blank. When not sent simultaneously to all, the order must be sent first to the superior train; sometimes it is impossible to get all the offices at once, in which case the superior train must have its orders sent first. This is in accordance with one of the cardinal principles of moving trains by telegraph, namely, that the superior train must be first advised of any change in its rights, and after its response is on record in the despatcher's book, inferior trains can be given orders.

Operators receiving train orders must write them in manifold during transmission. If they cannot at one writing make the requisite number of copies, they must trace others from one of the copies first made, so as to insure that the second lot of orders are exact duplicates of the first one. Some roads require that when the operator cannot at one writing make the requisite number of copies, the despatcher must repeat the order to the operator anew for the additional copies, and the operator again repeat and receive the usual responses as at the first transmission.

When a 31 train order has been transmitted, operators must (unless otherwise directed) repeat it at once from the manifold copy in the succession in which the several offices have been addressed, and then write the time of repetition on the order. Each operator receiving the order should observe whether the others repeat correctly. When the order is repeated and the exact time indorsed on the order, it should be presented to those (except enginemen) to whom the order is addressed, who will then read it aloud to the operator to make sure that it is understood. It is to be

signed as a notice and record that it is understood, and when these signatures, preceded by the number of the order, are sent to the proper officer, the response complete, and the time, with the initials of the proper official, will be given by the train despatcher, which is his notice that the order is recorded and ready for execution. The operator then writes the word complete on the order, and indorses it with his own name and the exact time. It is now ready to be delivered to the persons that are to execute it, each person addressed being entitled to a correct and legible copy. The copy for the engineman must be delivered to him personally by the man in charge of the train, and it is a safe precaution to require the engineman to read it aloud to the person that gives it to him. The rules of different roads vary as to the duties of the engineman; some require him to sign the orders personally, while others have the conductor or pilot sign them. The blánk form of train orders in use on each road specifies who shall sign these orders and at what places on the form, by providing a place and indicating whose name must appear there.

**11. Preparing Form 19.**—The manner in which a Form 19 order is to be prepared for delivery may be minutely detailed as follows: When a Form 19 train order has been transmitted, operators must (unless otherwise directed) repeat it at once from the manifold copy, in the succession in which the several offices have been addressed. Each operator receiving the order should observe whether the others repeat correctly. When the order has been repeated correctly by an operator, the response complete, the time, and the initials of the official will be given by the train despatcher. The operator receiving this response will then write on each copy the word complete, the time, and his last name in full, and personally deliver a copy to each person addressed without taking his receipt for it. Form 19 does not require the signature of the conductor but only that of the operator, who can deliver it to the conductor and engineman without any further signature, or without their reading it back to him; this shows that

Form 19 order is not as important as Form 31 order, as it is used for movements that the train despatcher from his record knows can be safely made without the use of Form 31. There is such a variance in opinion as to the safe use that can be made of the Form 19 that the student should carefully study the methods of the company by whom he is employed.

It is sometimes considered desirable for the receipt of an order to be acknowledged by the operator to the despatcher without repeating back. Rule 212 provides for this, as it says that a train order may, when so directed by the train despatcher, be acknowledged without repeating, by the operator responding as follows: "X; (Number of Train Order) to (Train Number)," with the operator's initials and office signal. The operator must then write on the order his initials and the time.

In no case must the word complete be given to a train order for delivery to an inferior train until it is certain that the order for the superior train has been repeated back to the despatcher, or that the X response mentioned in Rule 212 has been sent by the operator that is charged with the duty of delivering orders to the superior train; in other words, the superior train must be held first, before the inferior train can proceed.

**12. Non-Completion of Order.**—It sometimes happens that, after the train order has been repeated or the "X" response has been given, the word "complete" cannot be sent to the operator, in which case the order is not made complete. In such a case, after the order is repeated or "X" given, the order is a holding order for that train. If the wire is down, this will result in tying up that train, but it is the only safe plan, as on the "X" response, or the repeating of the order, a train is held and cannot proceed until the order is completed. But in case the wire fails after the order is sent, and before the "X" response is given, or before it has been repeated back to the despatcher, whichever method prevails on the road on which one is employed, this order has not arrived at the stage when it has any effect either as a holding

order or as a running order; therefore, it has no effect at all. Just how the operator will notify the train thus held that the order is in this condition is a matter each company settles for itself; but a clearance card made out in the proper form, stating the case, should be sufficient warrant for the train to proceed. As the student will perceive later, the train-order signal has by this time been displayed to stop the train, and is probably out at the time it is definitely settled that the wire has failed; what the train needs in this case is some authority to proceed after being stopped by the fixed signal.

**13. Duplicates of Order.**—It is provided, when issuing train orders, that the operator shall retain and preserve the bottom copy. The copies on top are usually the plainest and the train crew is entitled to them. As a portion of the carbon sheet is transferred by the pressure of the stylus to the tissue paper, if the carbons are not good the duplicate copies will not be perfect.

When the train despatcher delivers train orders personally, the orders are made out precisely as when delivered at any other office. It is further provided that such orders must be first written in manifold, so as to leave an impression in the record book from which transmission shall be made.

**14. Delivery of Order at a Non-Telegraph Station.** A train order that is to be delivered to a train at a point that is either not a telegraph station or at which the telegraph office is closed, must be addressed to "C and E________ (at________), care of________," and forwarded and delivered by the conductor or other person in whose care it is addressed. When Form 31 is used, "complete" will be given on the signature of the person by whom the order is to be delivered, and this person must be supplied with copies for the conductor and engineman addressed, and also the copy on which he shall take their signatures. This copy he must deliver to the first operator accessible, who must preserve it and at once transmit the signatures of the conductor and engineman to the train despatcher. This prescribes that three copies must be taken by the person that is

charged with the duty of delivering the order to the train mentioned, one copy for the conductor and one for the engineman; each of these men must compare the orders and sign for them on the third copy, which is the record for the messenger that has delivered the orders. He should require each person to whom the order is delivered to read it aloud to him, at the same time comparing it with the copy in his possession on which their signatures are obtained. He should also see that the order is understood alike by those concerned in its execution. This messenger then notifies the train despatcher at the next open telegraph office that the trainmen understand and will act on the order; their signatures are evidence of this. Orders so delivered must be acted on as if complete had been given in the usual manner.

For orders that are sent to a train in the manner herein provided, the superiority of which train is thereby restricted, complete must not be given to an inferior train until the signature of the conductor of the superior train has been sent to the proper officer. This is the same precaution that is taken with any form of train orders in which the rights of trains are changed.

**15. Meaning of Word Train in an Order.**—When a train is named in a train order, all its sections are included, unless particular sections are specified; and each section included must have copies addressed and delivered to it. For instance: If you have an order to meet a train by its number, and if, on its arrival, this train is found to be carrying signals for a following section, then your order will require you to meet all sections of that train at the same place, because the order specified the train by its number, which includes all sections. If, however, the order specifies particular sections of a train, only those particular sections need be looked out for, unless it is a superior train. In the meeting orders for the sections, each one specified therein must have copies addressed and delivered to it. A train, or any section of a train, must be governed strictly by the terms of orders addressed to it and must not assume rights

not conferred by such orders. In all other respects it must be governed by the train rules and time-tables. The movement of trains under the authority of signals carried for them by preceding trains may at first seem a little complicated, but if the true principle on which these trains derive their authority is considered, there need be no complication.

**16. Giving the X Response.**—Unless otherwise directed, an operator must not repeat or give the X response to a train order for a train the engine of which has passed his train-order signal, until he has ascertained that the conductor or engineman has been notified that he has orders for them; for if the engine has once passed the train-order signal set at "proceed," it is possible that the engineer may not be able to see this signal again.

Repeating the order or giving the X response is a notice to the despatcher that the train is being held, or that the signal is set to "stop" before the arrival of the train and the passage of the engine by the stop signal. It is customary to get the signature of the conductor to the order after he has ascertained beyond a doubt that the engineer is advised that the train is held.

**17. Life of Train Order.**—Train orders once in effect continue so until fulfilled, superseded, or annulled. Any part of an order specifying a particular movement may be either superseded or annulled. When a regular train loses both right and class (by Rules 4 and 82), the orders held by, or issued for, that train become void; in other words, that train is annulled or outlawed.

According to this rule, train orders issued to an extra train are, unless they have some time limitation, good until fulfilled, even if they run over until another day. Of course, the officer having authority to issue a train order can at any time supersede or annul any part of the order, the rest of it remaining in effect; in the case of a train order issued to a regular train, there is a time limitation implied that becomes effective when the train loses right and class, as provided by Rule 82. When

these train orders become void for this train, they are also void for all trains affected by them, and other trains can proceed.

**18. Fulfilling, Superseding, or Annulling an Order.** Train orders remain in force until fulfilled, superseded, or annulled. An order is *fulfilled* when the purpose for which it was issued is accomplished. For instance, an order is issued stating that "No. 1 will meet No. 2 at A." The order is fulfilled when both trains have arrived at that place. An order is *superseded* when its provisions are changed before it is fulfilled. For instance, Nos. 1 and 2 have the following order: "No. 1 will meet No. 2 at A." This may be superseded by the following: "No. 1 will meet No. 2 at B instead of A." A portion of an order may be superseded in this manner, leaving the remaining portion still in effect. An order is *annulled* by the issuing of a subsequent order stating that order No. (giving its number) is annulled. When an order has been superseded or annulled, it cannot be restored under its original number.

**19. Rule 221.**—Forms of the rules that relate to train-order signals are given in the Standard Code. See Rule 221, page 28. **Form A** of this rule states that a fixed signal must be used at each train-order office, which shall indicate "stop" when there is an operator on duty, except when changed to "proceed" in order to allow a train to pass after getting its orders, or for which there are no orders. A train must not pass the signal while stop is indicated. The signal must be returned to stop as soon as the train has passed. It must be fastened at proceed when no operator is on duty. Operators must have the proper appliances for hand signaling ready for immediate use in case the fixed signal should fail to work properly. These are a red flag by day and a red light by night. If a signal is not displayed at a night office, trains that have not been notified must stop and ascertain the cause, and report the facts to the proper officer from the next open telegraph office. See Rule 27.

**20.** When the semaphore is used, the arm indicates stop when horizontal and proceed when in an inclined position.

This provides that the normal position of the signal must be stop at all times when an operator is on duty. If the train is to proceed without getting orders, the operator will change the position of signal to proceed, and the signal must also be changed after the orders—if any—have been delivered. This form insures that unless the operator changes the signal to allow the train to pass, all trains will come to a stop. The conditions that affect trains at stations vary so much that each road adopts such regulations supplementary to this rule as may best suit its own requirements.

**21.** **Form B** of Rule 221 arranges for a different method, by which the normal position of the signal shall be at proceed. The rules state that at each train-order office a fixed signal must be used, which shall indicate stop, when trains are to be stopped for train orders, and indicate proceed when there are no orders. If there is no fixed signal, or if it is out of order, a red flag by day, and a red light by night must be used, and these signals must be displayed so that approaching trains can see them. They must not be located where there is any danger of their being hidden by persons standing in front of them. All trains must stop before passing the signal and must not proceed until it is changed to proceed, or until they receive a clearance card properly filled out. Rule 27 applies to both Forms A and B of Rule 221.

When an operator receives the signals "31" or "19," he must immediately display the stop signal and then reply "stop displayed"; and until the orders have been delivered or annulled, the signal must not be restored to proceed. While stop is indicated, trains must not proceed without a clearance card, for which a form is provided by the Standard Code, or by orders properly made out, or both clearance and orders. The rules of some roads require trains to obtain a clearance on the prescribed form in addition to train orders when the stop signal is displayed.

**22.** **Keeping Record of Train Movements.**—In order that the train despatcher may be informed of the exact whereabouts of all trains, a record of their movements must be kept

showing their departure, and, in the case of extra trains, their direction also. Rule 222 explicitly states that operators will promptly record and report to the proper officers the time of departure of all trains and the direction of extra trains. They will record the time of arrival of trains and report it when so directed.

Messages and train orders crowd each other so closely on a busy wire that brevity is a very important consideration. Many signs and abbreviations are used that are officially sanctioned, so that all concerned are acquainted with their exact meaning. Those provided in the Standard Code are:

C & E—for conductor and engineman.

X—Train will be held until order is made complete.

Com—for complete.

O S—Train report.

No—for number.

Eng—for engine.

Sec—for section.

Psgr—for passenger.

Frt—for freight.

Mins—for minutes.

Jct—for junction.

Despr—for train despatcher.

Opr—for operator.

31 or 19—to clear the line for train orders, and for operators to ask for train orders.

S D—for stop displayed.

Usual abbreviations for the names of the months and stations.

Initials for signatures of the superintendent, by whom such office and other signals are arranged.

Other abbreviations are used by the different roads, as may seem to them desirable.

General Note.—The forms of train orders will be found on page 29.

## FORMS OF ORDERS

**23. Form A.**—This form simply designates a meeting point for the two trains named, and is fulfilled when the trains have arrived at the point designated. It gives a train of inferior right (named in the order) the right over the other train (also named) to the point designated, and the train of superior right must remain at that point for the other train unless the order is superseded or annulled. This form of order is for single track. It is omitted from the list of orders applicable to double track.

**24. Form B.**—Under example 1, both trains will run according to rule to the designated point and there arrange for the rear train to pass promptly. In example 2, the leading train should keep a close watch for the following train and allow it to pass promptly when overtaken. Example 3 gives the first-mentioned train the right to run ahead of the second-named train to the designated point. When the first-named train reaches the designated point, the order is fulfilled, and the further movement of this train must be governed by time-table rights. The second-named train must not exceed the speed of the first-named train between the points designated. This form of order is used on both single and double track. The double-track forms of orders are all identified by the initial letter *D* before the form, as *D–Form B*.

**25. Form C.**—This form is practically a reversal of the rights given to one train over another by the rules. Under the rules, No. 2 East may have the right over No. 1 West; but under the operation of this form, as shown in example 1, page 30, the rights will be reversed and No. 1 will have the right over No. 2 between the points named in the order, and No. 2 must clear the time of No. 1 between those points as many minutes as No. 1 must clear No. 2 when the trains are running on the rights given by the schedule. If the trains are of the same class and the rules provide for variation, No. 1 must observe it the same as No. 2 would be required to do under the rules. If the trains named are not of the same

class, and No. 2 is of superior class to No. 1, No. 2 will, under the operation of this form (see example 1, page 30), be required to clear the time of No. 1 as many minutes as No. 1 is required by the rules to clear the time of No. 2. Under this form, No. 2 may, on arrival at the station last named in the order, proceed, if it can do so and clear the time of No. 1, as provided; but the conductor must stop No. 1 when they meet and notify it of his arrival. If No. 2 reaches the station first named in the order before meeting No. 1, it can proceed in accordance with rights given by the schedule. If No. 1 has not met No. 2 on arriving at the station last named in the order, and no further orders are received, the train must be governed by the schedule, which, if on single track, will require it to take side track and wait for No. 2.

Example 2, page 30, is used to give an extra train the right over another train to a given point. Under its operation, the second-named train must not pass the station last named until the extra has arrived, for the extra train has no schedule by which the opposing train can be governed.

Example 3, page 31, is designed to give a certain train the right over all trains between designated points, either indefinitely or until a specified time shown in the order, and other trains must not go within those limits until the order is annulled or its time limit expired.

**26. Form D.**—This form is used to give regular trains the right over another regular train named in the order, and the train over which the other trains are given the right must clear the time of all regular trains the same as if it were an extra train. It will thus be seen that this form of order takes away the schedule rights of the train over which regular trains are given the right, making it an extra train so far as the right to move is concerned; this train will not carry white signals, however. This form of order is not applicable to double track.

**27. Form E.**—A train order issued under this form is simply an extension of the schedule of the train whose right is restricted by the order.

Under examples 1 and 2, page 31, the train named in the order must not run between the stations named in the order a less number of minutes later than is specified in the order, and any other train receiving the order can run on the schedule shown in the train order the same as it was before permitted to run on the time-table schedule.

The subject of allowing for variation of watches (a practice still retained by companies using the Standard Code), while working under this form of order, and where the opposing trains are of the same class, should be clearly defined and understood. For instance, suppose that No. 2 is due to leave A at 10:30 A. M., and receives the following order: "No. 2 will run 1 hour late A to D." No. 1 is a train of the same class going in the opposite direction, and is due at A at 11:25 A. M. Should No. 2 wait at A the usual time required for variation of watches if No. 1 has not arrived at 11:30 A. M.? At the schedule meeting point of these trains No. 1 has the right of track up to the leaving time of No. 2, and if No. 1 does not arrive on time, No. 2 must wait the required time for variation before proceeding. The same principle will hold good in the case just referred to. No. 2, due to leave at 10:30 A. M., with an order to run 1 hour late A to D, cannot leave A before 11:30 A. M.; and No. 1, a train of the same class going in the opposite direction, due at A at 11:25 A. M., and holding the same order, has the right of track to that place against No. 2 until 11:30 A. M. It should therefore be understood that a train receiving an order to run late must wait the required time for variation of watches, as prescribed by the rules of the road on which the train is running, in addition to the time prescribed in the order, when the schedule time of a train of the same class going in the opposite direction is met.

Under example 3, page 31, the same principle of variation and clearance prevails. If No. 2 receives an order as follows: "No. 2 will wait at A until 11:30 A. M. for No 1," it would have to wait the required time for variation if No. 1 failed to arrive by the time prescribed in the order, the trains being of

the same class. If, however, the order given to No. 2 requires it to wait until 11:30 A. M. for an inferior train, the latter must clear the specified time the same as it is required under the rules to clear the schedule time of No. 2, and the latter may go at the expiration of the time specified in the order, whether the other train has arrived or not. This form is used on both single and double track.

**28. Form F.**—There is but little that can be said in explanation of this form, which deals with the running of trains in sections. The essential point in the movement of trains in this manner is a thorough understanding of the rights of trains running in sections and a proper observance of signals carried by trains, which points have been dealt with elsewhere. This form adds to the number of regular trains to be met. If you meet all the added trains the same as if they were on the printed time-table, there should be no chance of going astray, as the time-table provides for the meeting points of the other regular trains, whether they come behind or between the sections that are running under signals carried by preceding sections.

A green signal is expected to give the same time-table rights to following sections as the first section has, and no more. The rule in regard to this right, which was formerly in the Standard Code, said: "Two green flags by day and night, and, in addition, two green lights by night, displayed in the places provided for that purpose on the front of an engine, denote that the train is followed by another train, running on the same schedule and entitled to the same time-table rights as the train carrying the signals." This rule has been changed to Rule 20. Rules 95, 96, and 218 also speak of this matter. This form of order is used on both single and double track.

**29. Form G.**—This form provides for the movement of trains not shown on the time-tables, and the explanations given in the book of rules are so plain that nothing can be added. See Rules 81, 86, 87, 88, and 89. This form of order is used on both single and double track.

**30. Form H.**—This form is used for moving work trains, and other trains affected by them, over work-train limits. Under example 1, the work extra receiving the order has the right of track between the stations named in the order, keeping clear of regular trains (as provided in the rules) until the expiration of the time specified in the order, at which time they should be out of the way and clear of the main track. Example (*a*), page 33, is similar except that it provides for the running of the work extra from one specified point to another and for working between the last-named point and another point mentioned in the order until a specified time. This form gives the right to run from the first point to the second point, and to work between that point and the third point, keeping clear of regular trains as provided in the rules. This order will not permit the work extra to stop between the two stations first named, without protection required by the rules. If example (*b*), page 33, is added to the above, the work extra must, after the time named, keep clear of, or protect against, the extra train named in the order, as the order may require. If the order requires the work extra to keep clear of the extra train, it must be out of the way strictly at, or before, the time named in the order. If the order requires the work extra to protect against the extra train, the flagman must be out a sufficient distance with proper signals, as required by the rules, at or before the time named in the order. The extra train receiving this order must not go within the limits named in the order until the time has expired, unless the work extra should be met at the station, which defines the limits of its working order. If the order states that the work extra is protecting itself against the extra train, the latter must proceed with caution, keeping a close lookout for flagmen. On roads whose rules require allowance of time for variation on time orders, the extra train shall observe such time as the rules require before passing within the limits of the work extra. When an extra train is given an order to protect itself against a work extra, as in example (*c*), page 33, it must be carefully protected by flagmen, as required by the rules, expecting to find the work

extra moving in either direction without protection. When a work extra is given an order to protect itself, as in example (*d*), page 34, it must protect itself in both directions at all times as required by the rules. Example (*e*), page 34, gives the work extra the right to work on the time of the regular train named in the order, by protecting itself as required by the rules; and the regular train must proceed with caution over the limits of the work extra, expecting to find it.

For the safe movement of other trains over the limits of a work extra, the two essential things are adequate protection on the part of those on whom the duty of protection is placed, and the exercise of extreme caution on the part of those in charge of other trains. With these requirements faithfully observed, the movement can be made with absolute safety, while if they are neglected it is attended with great danger. The forms of orders given to work extras on double track differs from that used on single track, as it specifies on which of the two tracks the work extra can work, or gives it a right to work on both tracks. In case the trains are moving against the current of traffic on double tracks, the order specifies that proper protection be given. D–Form H gives a number of examples of the use of this order.

**31. Form J.**—This form is used on both single and double tracks for holding a train or trains at any station for any purpose that may be deemed necessary. Holding orders are addressed to the operator, but must be respected and observed by conductors and enginemen as if addressed to them. They must sign for the holding order and each must receive a copy of it. When a train is held by an order in this form, it cannot proceed until the order to hold is annulled (this annulling order will be addressed to the operator), or an order is received (addressed to the operator) stating that the train may go. Although in Form J these orders are addressed to the operator, trainmen and enginemen receive copies and must respect them the same as if they were addressed to them.

No matter how many orders the train may have received at such a station, these other orders do not release it from the order to hold. This fact should be kept clearly in mind, as meeting orders are very apt to be sent to such trains while being thus held, and if acted on as a release from the order to hold, an accident might result.

**32. Form K.**—This form is used for annulling a regular train. When a train is annulled over any portion of the line, other trains will be run the same as if the train annulled were not shown on the time-table. If example 1, page 34, is used for the annulling order, employes should have a thorough understanding in regard to it, as different interpretations are placed on it by different roads. For example, if No. 1 is due to leave its initial point on the first division at 10:00 P. M. and is to pass to the second division at 2:00 A. M., it would start on its trip on the latter division on another date. If the stations (shown in the train order) between which the train is annulled are on the second division, the question arises: Would the date shown in the order on which the train is annulled be the date on which it starts from its initial point on the first division, or is it the date on which it leaves its initial point in the second division—the division on which the annulling order is given? This is a matter that should be clearly defined and understood by all concerned, according to the rules of their particular road. Example 2, page 34, is preferable, as it is clearer in meaning, more easily understood, and not susceptible to different interpretations. Example 1, page 34, is plain enough on a road of only one division. The use of this form of order is alike on single and double tracks.

**33. Form L.**—This form is used for annulling a train order; and an order annulled in this manner will be considered the same as if it had not been sent. For example, if No. 1 has order No. 9 stating that "No. 1 will meet No. 2 at A" and is subsequently given an order stating that "Order No. 9 is annulled," No. 1 will proceed on the rights given by the schedule or other orders in its possession. As the order

annulled is designated by its number, the essential point is to see that the number shown in the annulling order agrees with the number of the order in possession of the trainmen by whom the annulling order is received. This is particularly important when there is more than one order in the possession of the trainmen. This order is used on both single and double track.

**34. Form M.**—This form is used to annul part of an order, the part annulled being specified in the annulling order. The balance of the order remains in force until fulfilled, superseded, or annulled by subsequent order. This form of order is used on both single and double tracks.

**35. Form P.**—This form is used for superseding an order or a part of an order, and the superseding order will take the place of the former order or that particular part of it to which it refers. If the order supersedes a part of an order only, the remaining portion will continue in force until fulfilled, superseded, or annulled by subsequent order. This form of order is used on both single and double tracks.

**36. D-Form R.**—It sometimes becomes necessary to use one of the double tracks to move a train or trains against the current of traffic, that is, in an opposite direction to the one trains move in obedience to Rule D–151.

When such an emergency arises, D–Form R is used. In the instructions governing the use of this form of train order, it is first specified that a train must not be moved against the current of traffic until the track on which it is to be run has been cleared of all opposing trains, which first requires that holding orders for all trains be put out at the station where the specified train is to enter the track against the current of traffic. After the track has been cleared of opposing trains, the effect of the order is to hold them until the train named in the order has arrived at the point last named in the order; or meeting orders can be issued the same as is the case on single track.

In case there is an inferior train between the points named in this order giving the specified train the right to move

against the current of traffic, which inferior train is moving in the same direction on the other track, it is specified that this inferior train shall receive a copy of the order and it may then proceed on its schedule, or right.

This may be stated in another way. Take the order given as an example: "No. 1 has right over opposing trains on No. 2 (or eastward) track Mecca to Mirbat." No. 1 normally runs on No. 1 or the west-bound track and the inferior train must look out for it on that track when its time is up. But as No. 1 in this case goes over on No. 2 track between Mecca and Mirbat, this train which is moving with the current of traffic and in the same direction as train No. 1 must be going westward on No. 1 track where it will not interfere with the movements of train No. 1. Therefore, a notice that train No. 1 is on the other track will be sufficient authority for the inferior train to proceed to Mirbat regardless of No. 1 between those points. This order is also given in a modified form stating that after a certain train arrives at the point first named in the order, the train that is to be moved against the current of traffic can proceed, and not before.

**37. D-Form S** provides for the use of one of the tracks as a single track between certain defined limits. The rule states that under this order all trains must use the track specified between the stations named and will be governed by rules for single track. Trains running against the current of traffic on the track named must be clear of the track at the expiration of the time named, or be protected as prescribed by Rule D–99.

This means that all double-track rules over the section of road designated to be used as a single track are abrogated while the order remains in effect, and all trains moving in either direction over it will be governed by rules for single track, as if no double track had ever existed on the designated section, and that the direction of right as between trains of the same class provided for in the time-table for single track of that road have superseded the double-track right of movement with the current of traffic for the time being.

Train Rules D-251 to D-254 and D-261 to D-264 (see also, Arts. **53** and **54**). *Train Rules*, Part 1, also provide for movements both *with* and *against* the current of traffic by block signals.

**38. Clearance Card.**—The clearance card is used to release trains for which there are no orders when the train-order signal is displayed at a telegraph station. On some roads, trains are required to receive a clearance card in addition to any orders that may be received. The clearance card should: (1) give the name of the station at which it was received, (2) the time received, (3) be correctly dated, (4) designate the train to which it is issued, (5) show that there are no further orders for the train to which it is issued, (6) show for what train or trains the train-order signal is displayed, and (7) be signed with the full name of the operator.

Some roads use a clearance card specifying the numbers of the orders delivered to the train receiving the clearance, when any are delivered with it. There is a blank space for such specification which, when no orders are issued with the clearance, is filled in "No." This provides a safeguard against any statement made by trainmen as to non-receipt of orders of Form 19 that have been violated or have not been obeyed by them on the plea of non-receipt, and protects the operator. It also tends to insure the delivery by the operator of all orders held by him for the train receiving the clearance card and fixes his responsibility in case of failure to deliver any order. There is equally as much depending on the proper use of the clearance card as on train orders, and its use should be well guarded.

Rule 221 B states that while "stop" is indicated a train must not proceed without a clearance card; which must be properly filled out and signed by the operator.

This provision requires that the operator delivering an order or orders to a train stopped by his signal, and holding orders for a following train, is forbidden to turn the signal to "clear" to let the train go, but must issue a clearance in addition to the order delivered.

# THE STANDARD CODE
OF THE
# AMERICAN RAILWAY ASSOCIATION

---

## RULES FOR MOVEMENT BY TRAIN ORDERS

---

### SINGLE TRACK

201. For movements not provided for by time-table, train orders will be issued by authority and over the signature of the ______. They must contain neither information nor instructions not essential to such movements.

They must be brief and clear; in the prescribed forms when applicable; and without erasure, alteration or interlineation.

202. Each train order must be given in the same words to all persons or trains addressed.

203. Train orders will be numbered consecutively each day, beginning with No. __ at midnight.

204. Train orders must be addressed to those who are to execute them, naming the place at which each is to receive his copy. Those for a train must be addressed to the conductor and engineman, and also to any one who acts as its pilot. A copy for each person addressed must be supplied by the operator.

205. Each train order must be written in full in a book provided for that purpose at the office of the ______; and with it recorded the names of those who have signed for the order; the time and the signals which show when and from what offices the order was repeated and the responses transmitted; and the train despatcher's initials. These records must be made at once; and never from memory or memoranda.

206. Regular trains will be designated in train orders by their numbers, as "No. 10," or "2d No. 10," adding engine numbers if desired; extra trains by engine numbers, as "Extra 798," with the direction when necessary, as "East" or "West." Other numbers and time will be stated in figures only.

207. To transmit a train order, the signal "31" or the signal "19" must be given to each office addressed, the number of copies being stated, if more or less than three—thus, "31 copy 5," or "19 copy 2."

NOTE TO RULE 207.—Where Forms "31" and "19" are not both in use the signal may be omitted.

208. A train order to be sent to two or more offices must be transmitted simultaneously to as many of them as practicable. The several addresses must be in the order of superiority of trains, each office taking its proper address. When not sent simultaneously to all, the order must be sent first to the superior train.

209. Operators receiving train orders must write them in manifold during transmission and if they cannot at one writing make the requisite number of copies, must trace others from one of the copies first made.

210. When a "31" train order has been transmitted, operators must (unless otherwise directed) repeat it at once from the manifold copy in the succession in which the several offices have been addressed, and then write the time of repetition on the order. Each operator receiving the order should observe whether the others repeat correctly.

Those to whom the order is addressed, except enginemen, must then sign it, and the operator will send their signatures preceded by the number of the order to the ______. The response "complete," and the time, with the initials of the ______, will then be given by the train despatcher. Each operator receiving this response will then write on each copy the word "complete," the time, and his last name in full, and then deliver a copy to each person addressed, except enginemen. The copy for each engineman must be delivered to him personally by ____ .

NOTE TO RULE 210.—The blanks in the above rule may be filled for each road to suit its own requirements. On roads where the signature of the engineman is desired, the words, "except enginemen," and the last sentence in the second paragraph may be omitted. If preferred, each person receiving an order may be required to read it aloud to the operator.

211. When a "19" train order has been transmitted, operators must (unless otherwise directed) repeat it at once from the manifold copy, in the succession in which the several offices have been addressed. Each operator receiving the order should observe whether the others repeat correctly. When the order has been repeated correctly by an operator, the response "complete," and the time, with the initials of the ______, will be given by the train despatcher. The operator receiving this response will then write on each copy the word "complete," the time, and his last name in full, and personally deliver a copy to each person addressed without taking his signature.

212. A train order may, when so directed by the train despatcher, be acknowledged without repeating, by the operator responding:

"X; ______(Number of Train Order)______ to ______(Train Number)______," with the operator's initials and office signal. The operator must then write on the order his initials and the time.

213. "Complete" must not be given to a train order for delivery to an inferior train until the order has been repeated or the "X" response sent by the operator who receives the order for the superior train.

214. When a train order has been repeated or "X" response sent, and before "complete" has been given, the order must be treated as a holding order for the train addressed, but must not be otherwise acted on until "complete" has been given.

If the line fails before an office has repeated an order or has sent the "X" response, the order at that office is of no effect and must be there treated as if it had not been sent.

215. The operator who receives and delivers a train order must preserve the lowest copy.

216. For train orders delivered by the train despatcher the requirements as to the record and delivery are the same as at other offices.

Such orders shall be first written in manifold so as to leave an impression in the record book, from which transmission shall be made.

217. A train order to be delivered to a train at a point not a telegraph station, or at one at which the telegraph office is closed, must be addressd to

*C. and E. ______ (at ______), care of ______,"*

and forwarded and delivered by the conductor or other person in whose care it is addressed. When Form 31 is used "complete" will be given upon the signature of the person by whom the order is to be delivered, who must be supplied with copies for the conductor and engineman addressed, and a copy upon which he shall take their signatures. This copy he must deliver to the first operator accessible, who must preserve it, and at once transmit the signatures of the conductor and engineman to the train despatcher.

Orders so delivered must be acted on as if "complete" had been given in the usual way.

For orders which are sent, in the manner herein provided, to a train, the superiority of which is thereby restricted, "complete" must not be given to an inferior train until the signatures of the conductor and engineman of the superior train have been sent to the ______.

218. When a train is named in a train order, all its sections are included unless particular sections are specified, and each section included must have copies addressed and delivered to it.

219. Unless otherwise directed, an operator must not repeat or give the "X" response to a train order for a train, the engine of which has passed his train-order signal, until he has ascertained that

the conductor and engineman have been notified that he has orders for them.

220. Train orders once in effect continue so until fulfilled, superseded or annulled. Any part of an order specifying a particular movement may be either superseded or annulled.

Orders held by or issued for a regular train become void when such train loses both right and class as prescribed by Rules 4 and 82, or is annulled.

221 (A). A fixed signal must be used at each train-order office, which shall indicate "stop" when there is an operator on duty, except when changed to "proceed" to allow a train to pass after getting train orders, or for which there are no orders. A train must not pass the signal while "stop" is indicated. The signal must be returned to "stop" as soon as a train has passed. It must be fastened at "proceed" only when no operator is on duty.

Operators must have the proper appliances for hand signaling ready for immediate use if the fixed signal should fail to work properly. If a signal is not displayed at a night office, trains which have not been notified must stop and ascertain the cause, and report the facts to the ____ from the next open telegraph office.

Where the semaphore is used, the arm indicates "stop" when horizontal and "proceed" when in an inclined position.

NOTE TO RULE 221 (A).—The conditions which affect trains at stations vary so much that it is recommended each road adopt such regulations supplementary to this rule as may best suit its own requirements.

221 (B). A fixed signal must be used at each train-order office, which shall indicate "stop" when trains are to be stopped for train orders. When there are no orders the signal must indicate "proceed."

When an operator receives the signal "31," or "19," he must immediately display the "stop signal" and then reply "stop displayed"; and until the orders have been delivered or annulled the signal must not be restored to "proceed." While "stop" is indicated trains must not proceed without a clearance card [Form ____ (A) ].

Operators must have the proper appliances for hand signaling ready for immediate use if the fixed signal should fail to work properly. If a signal is not displayed at a night office, trains which have not been notified must stop and ascertain the cause, and report the facts to the ____ from the next open telegraph office.

Where the semaphore is used, the arm indicates "stop" when horizontal and "proceed" when in an inclined position.

NOTE TO RULES 221 (A) AND 221 (B).—The Committee has recommended two forms of Rule 221, leaving it discretionary to adopt one or both of these forms according to the circumstances of the traffic.

222. Operators will promptly record and report to the ____ the time of departure of all trains and the direction of extra trains. They will record the time of arrival of trains and report it when so directed.

223. The following signs and abbreviations may be used:

Initials for signature of the ____.

Such office and other signals as are arranged by the ____.

C & E—for Conductor and Engineman.

X—Train will be held until order is made "complete."

Com—for Complete.

O S—Train Report.

No—for Number.

Eng—for Engine.

Sec—for Section.

Psgr—for Passenger.

Frt—for Freight.

Mins—for Minutes.

Jct—for Junction.

Despr—for Train Despatcher.

Opr—for Operator.

31 or 19—to clear the line for Train Orders, and for Operators to ask for Train Orders.

S D—for "Stop Displayed."

The usual abbreviations for the names of the months and stations.

General Note.—Blanks in the rules may be filled by each road to suit its own organization or requirements.

---

## FORMS FOR TRAIN ORDERS FOR SINGLE TRACK

---

### FORM A. FIXING MEETING POINTS FOR OPPOSING TRAINS

(1) ____ will meet ____ at ____.

(2) ____ will meet ____ at ____ ____ at ____ (and so on).

EXAMPLES

(1) *No 1 will meet No 2 at Bombay.*

*No 3 will meet 2d No 4 at Siam.*

*No 5 will meet Extra 95 at Hong Kong.*

*Extra 652 North will meet Extra 231 South at Yokohama.*

(2) *No 1 will meet No 2 at Bombay 2d No 4 at Siam and Extra 95 at Hong Kong.*

Trains receiving these orders will run with respect to each other to the designated points and there meet in the manner provided by the Rules.

### FORM B. DIRECTING A TRAIN TO PASS OR RUN AHEAD OF ANOTHER TRAIN

(1) _____ will pass _____ at _____.
(2) _____ will pass _____ when overtaken.
(3) _____ will run ahead of _____ _____ to _____.
(4) _____ will pass _____ at _____ and run ahead of _____ _____ to _____.

EXAMPLES

(*1*) *No 1 will pass No 3 at Khartoum.*
(*2*) *No 6 will pass No 4 when overtaken.*
(*3*) *Extra 594 will run ahead of No 6 Bengal to Madras.*
(*4*) *No 1 will pass No 3 at Khartoum and run ahead of No 7 Madras to Bengal.*

When under (1) a train is to pass another both trains will run according to rule to the designated point and there arrange for the rear train to pass promptly.

Under (2), both trains will run according to rule until the second-named train is overtaken and then arrange for the rear train to pass promptly.

Under (3), the second-named train must not exceed the speed of the first-named train between the points designated.

---

### FORM C. GIVING A TRAIN THE RIGHT OVER AN OPPOSING TRAIN

_____ has right over _____ _____ to _____.

EXAMPLES

(*1*) *No 1 has right over No 2 Mecca to Mirbat.*
(*2*) *Extra 37 has right over No 3 Natal to Ratlam.*

This order gives the train first named the right over the other train between the points named.

If the train meets at either of the designated points, the first-named train must take the siding, unless the order otherwise prescribes.

Under (1), if the second-named train reaches the point last named before the other arrives it may proceed, keeping clear of the opposing train as many minutes as such train was before required to clear it under the Rules.

If the second-named train, before meeting, reaches a point within or beyond the limits named in the order, the conductor must stop the other train where it is met and inform it of his arrival.

Under (2), the regular train must not go beyond the point last named until the extra train has arrived.

When the extra train has reached the point last named the order is fulfilled.

The following modification of this form of order will be applicable for giving a work extra the right over all trains in case of emergency:

(3) Work extra ______ has right over all trains between ______ and ______ from ____ m to ____ m.

EXAMPLE

*Work extra 275 has right over all trains between Stockholm and Edinburg from 7 p m to 12 midnight.*

This gives the work extra the exclusive right between the points designated between the times named.

---

### FORM D. GIVING REGULAR TRAINS THE RIGHT OVER A GIVEN TRAIN

Regular trains have right over ______ between ______ and ______.

EXAMPLE

*Regular trains have right over No 1 between Moscow and Berlin.*

This order gives to regular trains receiving it the right over the train named in the order, and the latter must clear the schedule times of all regular trains, as if it were an extra.

---

### FORM E. TIME ORDERS

(1) ______ will run ______ late ______ to ______.

(2) ______ will run ______ late ______ to ______ and ______ late ______ to ______ etc.

(3) ______ will wait at ______ until ______ for ______.

EXAMPLES

(*1*) *No 1 will run 20 min late Joppa to Mainz.*

(*2*) *No 1 will run 20 min late Joppa to Mainz and 15 min late Mainz to Muscat etc.*

(*3*) *No 1 will wait at Muscat until 10 a m for No 2.*

(1) and (2) make the schedule time of the train named, between the stations mentioned, as much later as stated in the order, and any other train receiving the order is required to run with respect to this later time, as before required to run with respect to the regular schedule time. The time in the order should be such as can be easily added to the schedule time.

Under (3) the train first named must not pass the designated station before the time given, unless the other train has arrived. The train last named is required to run with respect to the time specified, as before required to run with respect to the regular schedule time of the train first named.

**FORM F. FOR SECTIONS**

_____ will display signals _____ to _____ for _____.

EXAMPLES

*Eng 70 will display signals and run as 1st No 1 London to Paris.*

---

*No 1 will display signals London to Dover for Eng 85.*

---

*2d No 1 will display signals London to Dover for Eng 90.*

This form may be modified as follows:

*Engs 70 85 and 90 will run as 1st 2d and 3d No 1.*

---

*Engs 70 85 and 90 will run as 1st 2d and 3d No 1 London to Dover.*

Under these examples the engine last named will not display signals.

For annulling a section:

*Eng 85 is annulled as 2d No 1 from Chatham.*

If there are other sections following add:

*Following sections will change numbers accordingly.*

The character of a train for which signals are displayed may be stated. Each section affected by the order must have copies, and must arrange signals accordingly.

---

**FORM G. EXTRA TRAINS**

(1) Eng _____ will run extra _____ to _____.
(2) Eng _____ will run extra _____ to _____ and return to _____.

EXAMPLES

(*1*) *Eng 99 will run extra Berber to Gaza.*
(*2*) *Eng 99 will run extra Berber to Gaza and return to Cabul.*

A train receiving this order is not required to protect itself against opposing extra trains, unless directed by order to do so, but must keep clear of all regular trains, as required by rule.

(3) Eng _____ will run extra leaving _____ on _____ as follows with right over all trains.

Leave _____.
" _____.
Arrive _____.

EXAMPLE

(*3*) *Eng 77 will run extra leaving Turin on Thursday Feb 17th as follows with right over all trains.*

*Leave Turin 11 30 p m*
*" Pekin 11 25 a m*
*" Canton 1 47 a m*
*Arrive Rome 2 22 a m*

This order may be varied by specifying the kind of extra and the particular trains over which the extra shall or shall not have the right. Trains over which the extra is thus given the right must clear the time of the extra ______ minutes.

---

### FORM H. EXTRA WORK

(1) Work extra ______ will work ______ until ______ between ______ and ______.

EXAMPLES

(*1*) *Work extra 292 will work 7 a m until 6 p m between Berne and Turin.*

The working limits should be as short as practicable, to be changed as the progress of the work may require. The above may be combined, thus:

(*a*) *Work extra 292 will run Berne to Turin and work 7 a m until 6 p m between Turin and Rome.*

When an order has been given to "work" between designated points, no other extra shall be authorized to run over that part of the track without provision for passing the work extra.

When it is anticipated that a work extra may be where it cannot be reached for orders, it may be directed to report for orders at a given time and place, or an order may be given that it shall clear the track for (or protect itself after a certain hour against) a designated extra by adding to (1) the following words:

(*b*) *And will keep clear of* (*or protect against*) *Extra 223 south between Antwerp and Brussels after 2 10 p m.*

In this case, extra 223 must not pass the northernmost point before 2 10 p. m., at which time the work extra must be out of the way, or protected (as the order may require) between those points.

When the movement of an extra over the working limits cannot be anticipated by these or other orders to the work extra, an order must be given to such extra, to protect itself against the work extra, in the following form:

(*c*) *Extra 76 will protect against work extra 95 between Lyons and Paris.*

This may be added to the order to run extra.

A work extra when met or overtaken by an extra must allow it to pass.

When it is desirable that a work extra shall at all times protect itself while on working limits, it may be done by adding to (1) the following words:

(*d*) *protecting itself.*

A train receiving this order must, whether standing or moving, protect itself within the working limits in both directions in the manner prescribed by Rule 99.

Whenever an extra is given orders to run over working limits it must at the same time be given a copy of the order sent to the work extra.

To enable a work extra to work upon the time of a regular train, the following form may be used:

(*e*) *Work extra 292 will protect against No 55 between Berne and Turin.*

A train receiving this order will work upon the time of the train mentioned in the order, and protect itself against it as prescribed by Rule 99.

The regular train receiving this order must run, expecting to find the work extra protecting itself within the limits named.

---

### FORM J. HOLDING ORDER

Hold ______ at ______.

EXAMPLES

(*1*) *Hold No 2 at Berlin.*

(*2*) *Hold all eastbound trains at Berlin.*

This order will be addressed to the operator and acknowledged in the usual manner. It must be respected by conductors and enginemen of trains thereby directed to be held as if addressed to them.

When a train has been so held it must not proceed until the order to hold is annulled, or an order given to the operator in the form:

______ *may go.*

Form J will only be used when necessary to hold trains until orders can be given, or in case of emergency.

---

### FORM K. ANNULLING A REGULAR TRAIN

(1) ______ of ______ is annulled ______ to ______.

(2) ______ due to leave ______ ______ is annulled ______ to ______.

EXAMPLES

(*1*) *No 1 of Feb 29th is annulled Alaska to Halifax.*

(*2*) *No 3 due to leave Naples Saturday Feb 29th is annulled Alaska to Halifax.*

The train annulled loses both right and class between the stations named and must not be restored under its original number between those stations.

---

### FORM L. ANNULLING AN ORDER

"Order No ______ is annulled."

If an order which is to be annulled has not been delivered to a train, the annulling order will be addressed to the operator, who will destroy all copies of the order annulled but his own, and write on that:

*Annulled by Order No* ______.

EXAMPLE

*Order No 10 is annulled.*

An order which has been annulled must not be reissued under its original number.

In the address of an order annulling another order, the train first named must be that to which right was given by the order annulled, and when the order is not transmitted simultaneously to all concerned, it must be first sent to the point at which that train is to receive it and the required response made, before the order is sent for other trains.

---

### FORM M. ANNULLING PART OF AN ORDER

That part of Order No ______ reading ______ is annulled.

EXAMPLE

*That part of Order No 10 reading No 1 will meet No 2 at Sparta is annulled.*

In the address of an order annulling a part of an order, the train first named must be that to which right was given by the part annulled, and when the order is not transmitted simultaneously to all concerned, it must be first sent to the point at which that train is to receive it, and the required response made, before the order is sent for other trains.

---

### FORM P. SUPERSEDING AN ORDER OR A PART OF AN ORDER

This order will be given by adding to prescribed forms the words "instead of ______."

(1) ______ will meet ______ at ______ instead of ______.
(2) ______ has right over ______ ______ to ______ instead of ______.
(3) ______ will diplay signals for ______ ______ to ______ instead of ___ ___.

EXAMPLES

(1) *No 1 will meet No 2 at Hong Kong instead of Bombay.*

(2) *No 1 has right over No 2 Mecca to Medina instead of Mirbat.*

(3) *No 1 will display signals for Eng 85 Astrakhan to Teheran instead of Cabul.*

An order which has been superseded must not be reissued under its original number.

## RULES FOR MOVEMENT BY TRAIN ORDERS

### DOUBLE TRACK

D–201. For movements not provided for by time-table, train orders will be issued by authority and over the signature of the ______. They must contain neither information nor instructions not essential to such movements.

They must be brief and clear; in the prescribed forms when applicable; and without erasure, alteration or interlineation.

D–202. Each train order must be given in the same words to all persons or trains addressed.

D–203. Train orders will be numbered consecutively each day, beginning with No at midnight.

D–204. Train orders must be addressed to those who are to execute them, naming the place at which each is to receive his copy. Those for a train must be addressed to the conductor and engineman, and also to any one who acts as its pilot. A copy for each person addressed must be supplied by the operator.

D–205. Each train order must be written in full in a book provided for the purpose at the office of the ______; and with it recorded the names of those who have signed for the order; the time and the signals which show when and from what offices the order was repeated and the responses transmitted; and the train despatcher's initials. These records must be made at once, and never from memory or memoranda.

D–206. Regular trains will be designated in train orders by their numbers, as "No 10," or "2d No 10," adding engine numbers if desired; extra trains by engine numbers, as "Extra 798," with the direction when necessary, as "East" or "West." Other numbers and time will be stated in figures only.

D–207. To transmit a train order, the signal "31" or the signal "19" must be given to each office addressed, the number of copies being stated, if more or less than three—thus, "31 copy 5," or "19 copy 2."

NOTE TO RULE D–207.—Where Forms "31" and "19" are not both in use the signal may be omitted.

D–208. A train order to be sent to two or more offices must be transmitted simultaneously to as many of them as practicable. The several addresses must be in the order of superiority of trains, each office taking its proper address. When not sent simultaneously to all, the order must be sent first to the superior train.

D–209. Operators receiving train orders must write them in manifold during transmission and if they cannot at one writing make the requisite number of copies, must trace others from one of the copies first made.

D–210. When a "31" train order has been transmitted, operators must (unless otherwise directed) repeat it at once from the manifold copy in the succession in which the several offices have been addressed, and then write the time of repetition on the order. Each operator receiving the order should observe whether the others repeat correctly.

Those to whom the order is addressed, except enginemen, must then sign it, and the operator will send their signatures preceded by the number of the order to the ______. The response "complete," and the time, with the initials of the ______, will then be given by the train despatcher. Each operator receiving this response will then write on each copy the word "complete," the time, and his last name in full, and then deliver a copy to each person addressed, except enginemen. The copy for each engineman must be delivered to him personally by ______.

Note to Rule D–210.—The blanks in the above rule may be filled for each road to suit its own requirements. On roads where the signature of the engineman is desired, the words "except enginemen," and the last sentence in the second paragraph may be omitted. If preferred, each person receiving an order may be required to read it aloud to the operator.

D–211. When a "19" train order has been transmitted, operators must (unless otherwise directed) repeat it at once from the manifold copy, in the succession in which the several offices have been addressed. Each operator receiving the order should observe whether the others repeat correctly. When the order has been repeated correctly by an operator, the response "complete," and the time, with the initials of the ______, will be given by the train despatcher. The operator receiving this response will then write on each copy the word "complete," the time, and his last name in full, and personally deliver a copy to each person addressed without taking his signature.

D–212. A train order may, when so directed by the train despatcher, be acknowledged without repeating, by the operator responding: "X; ____(Number of Train Order)____ to __(Train Number)__," with the operator's initials and office signal. The operator must then write on the order his initials and the time.

D–213. "Complete" must not be given to a train order for delivery to an inferior train until the order has been repeated or the "X"

response sent by the operator who receives the order for the superior train.

D-214. When a train order has been repeated or "X" response sent, and before "complete" has been given, the order must be treated as a holding order for the train addressed, but must not be otherwise acted on until "complete" has been given.

If the line fails before an office has repeated an order or has sent the "X" response, the order at that office is of no effect and must be there treated as if it had not been sent.

D-215. The operator who receives and delivers a train order must preserve the lowest copy.

D-216. For train orders delivered by the train despatcher the requirements as to the record and delivery are the same as at other offices.

Such orders shall be first written in manifold so as to leave an impression in the record book, from which transmissions shall be made.

D-217. A train order to be delivered to a train at a point not a telegraph station, or at one at which the telegraph office is closed, must be addressed to

"*C and E* _____ (*at* _____), *care of* _____,"

and forwarded and delivered by the conductor or other person in whose care it is addressed. When Form 31 is used "complete" will be given upon the signature of the person by whom the order is to be delivered, who must be supplied with copies for the conductor and engineman addressed, and a copy upon which he shall take their signatures. This copy he must deliver to the first operator accessible, who must preserve it, and at once transmit the signatures of the conductor and engineman to the train despatcher.

Orders so delivered must be acted on as if "complete" had been given in the usual way.

For orders which are sent, in the manner herein provided, to a train, the superiority of which is thereby restricted, "complete" must not be given to an inferior train until the signatures of the conductor and engineman of the superior train have been sent to the ____.

D-218. When a train is named in a train order, all its sections are included unless particular sections are specified, and each section included must have copies addressed and delivered to it.

D-219. Unless otherwise directed, an operator must not repeat or give the "X" response to a train order for a train, the engine of which has passed his train-order signal, until he has ascertained that the conductor and engineman have been notified that he has orders for them.

D-220. Train orders once in effect continue so until fulfilled, superseded or annulled. Any part of an order specifying a particular movement may be either superseded or annulled.

Orders held by or issued for a regular train become void when such train loses both right and class as prescribed by Rules D–4 and D–82, or is annulled.

D–221 (A). A fixed signal must be used at each train-order office, which shall indicate "stop" when there is an operator on duty, except when changed to "proceed" to allow a train to pass after getting train orders, or for which there are no orders. A train must not pass the signal while "stop" is indicated. The signal must be returned to "stop" as soon as a train has passed. It must be fastened at "proceed" only when no operator is on duty.

Operators must have the proper appliances for hand signaling ready for immediate use if the fixed signal should fail to work properly. If a signal is not displayed at a night office, trains which have not been notified must stop and ascertain the cause, and report the facts to the ______ from the next open telegraph office.

Where the semaphore is used, the arm indicates "stop" when horizontal and "proceed" when in an inclined position.

NOTE TO RULE D–221 (A).—The conditions which affect trains at stations vary so much that it is recommended each road adopt such regulations supplementary to this rule as may best suit its own requirements.

D–221 (B). A fixed signal must be used at each train-order office, which shall indicate "stop" when trains are to be stopped for train orders. When there are no orders the signal must indicate "proceed."

When an operator receives the signal "31," or "19," he must immediately display the "stop signal" and then reply "stop displayed"; and until the orders have been delivered or annulled the signal must not be restored to "proceed." While "stop" is indicated trains must not proceed without a clearance card [Form ______ (A) ].

Operators must have the proper appliances for hand signaling ready for immediate use if the fixed signals should fail to work properly. If a signal is not displayed at a night office; trains which have not been notified must stop and ascertain the cause, and report the facts to the ______ from the next open telegraph office.

Where the semaphore is used, the arm indicates "stop" when horizontal and "proceed" when in an inclined position.

NOTE TO RULES D–221 (A) AND D–221 (B).—The Committee has recommended two forms of Rule D–221, leaving it discretionary to adopt one or both of these forms according to the circumstances of the traffic.

D–222. Operators will promptly record and report to the ______ the time of departure of all trains and the direction of extra trains. They will record the time of arrival of trains and report it when so directed.

D–223. The following signs and abbreviations may be used:

Initials for signature of the ______.

Such office and other signals as are arranged by the ______.

C & E—for Conductor and Engineman.

X—Train will be held until order is made "complete."

Com—for Complete.
O S—Train Report.
No—for Number.
Eng—for Engine.
Sec—for Section.
Psgr—for Passenger.
Frt—for Freight.
Mins—for Minutes.
Jct—for Junction.
Despr—for Train Despatcher.
Opr—for Operator.
31 or 19—to clear the line for Train Orders, and for Operators to ask for Train Orders.
S D—for "Stop Displayed."
The usual abbreviations for the names of the months and stations.

General Note.—Blanks in the rules may be filled by each road to suit its own organization or requirements.

---

## FORMS OF TRAIN ORDERS FOR DOUBLE TRACK

---

### FORM A. FIXING MEETING POINTS FOR OPPOSING TRAINS

Omitted. Not applicable to Double Track.

---

### D-FORM B. DIRECTING A TRAIN TO PASS OR RUN AHEAD OF ANOTHER TRAIN

(1) ______ will pass ______ at ______.
(2) ______ will pass ______ when overtaken.
(3) ______ will run ahead of ______ ______ to ______.
(4) ______ will pass ______ at ______ and run ahead of ______ ______ to ______.

EXAMPLES

(1) *No 1 will pass No 3 at Khartoum.*
(2) *No 6 will pass No 4 when overtaken.*
(3) *Extra 594 will run ahead of No 6 Bengal to Madras.*
(4) *No 1 will pass No 3 at Khartoum and run ahead of No 7 Madras to Bengal.*

When under (1) a train is to pass another both trains will run according to rule to the designated point and there arrange for the rear train to pass promptly.

Under (2), both trains will run according to rule until the second-named train is overtaken and then arrange for the rear train to pass promptly.

Under (3), the second-named train must not exceed the speed of the first-named train between the points designated.

---

**FORM C. GIVING A TRAIN THE RIGHT OVER AN OPPOSING TRAIN**

Omitted. Not applicable to Double Track.

---

**FORM D. GIVING REGULAR TRAINS THE RIGHT OVER A GIVEN TRAIN**

Omitted. Not applicable to Double Track.

---

**D-FORM E. TIME ORDERS**

(1) ______ will run ______ late ______ to ______.
(2) ______ will run ______ late ______ to ______ and ______ late ______ to ______ etc.

EXAMPLES

(*1*) *No 1 will run 20 min late Joppa to Mainz.*
(2) *No 1 will run 20 min late Joppa to Mainz and 15 min late Mainz to Muscat etc.*

(1) and (2) make the schedule time of the train named, between the stations mentioned, as much later as stated in the order, and any other train receiving the order is required to run with respect to this later time, as before required to run with respect to the regular schedule time. The time in the order should be such as can be easily added to the schedule time.

---

**D-FORM F. FOR SECTIONS**

______ will display signals ______ to ______ for ______.

EXAMPLES

*Eng 70 will display signals and run as 1st No 1 London to Paris.*

---

*No 1 will display signals London to Dover for Eng 85.*

---

*2d No 1 will display signals London to Dover for Eng 90.*

This form may be modified as follows:

*Engs 70 85 and 90 will run as 1st 2d and 3d No 1.*

---

*Engs 70 85 and 90 will run as 1st 2d and 3d No 1 London to Dover.*

Under these examples the engine last named will not display signals.

For annulling a section.

*Eng 85 is annulled as 2d No 1 from Chatham.*

If there are other sections following add:

*Following sections will change numbers accordingly.*

The character of a train for which signals are displayed may be stated. Each section affected by the order must have copies, and must arrange signals accordingly.

---

### D-FORM G. EXTRA TRAINS

(1) Eng ____ will run extra ____ to ____.
(2) Eng ____ will run extra ____ to ____ and return to ____.

EXAMPLES

(*1*) *Eng 99 will run extra Berber to Gaza.*
(*2*) *Eng 99 will run extra Berber to Gaza and return to Cabul.*

A train receiving this order must keep clear of all regular trains and of extra trains having right over it, as required by rule.

(3) Eng ____ will run extra leaving ____ on ____ as follows with right over all trains.

Leave ____.
" ____.
Arrive ____.

EXAMPLE

(*3*) *Eng 77 will run extra leaving Turin on Thursday Feb 17th as follows with right over all trains.*

*Leave Turin 11 30 p m*
" *Pekin 12 25 a m*
" *Canton 1 47 a m*
*Arrive Rome 2 22 a m*

This order may be varied by specifying the kind of extra and the particular trains over which the extra shall or shall not have the right. Trains over which the extra is thus given the right must clear the time of the extra ____ minutes.

---

### D-FORM H. WORK EXTRA

Eng ____ will work extra ____ until ____ between ____ and ____.

EXAMPLE

*Eng 292 will work extra 7 a m until 6 p m between Berne and Turin.*

This form of order must be combined with one of the following additions:

(*1*) "*On* (*eastward*) *track.*"
"*On* (*westward*) *track.*"
"*On* (*eastward and westward*) *track.*"

Under (1) the Work extra will protect on the track or tracks named as prescribed by Rule D–99. The time of regular trains must be cleared.

(*2*) "*On* (*eastward*) *track without protecting against extra trains.*"
"*On* (*westward*) *track without protecting against extra trains.*"
"*On* (*eastward and westward*) *track without protecting against extra trains.*"

Under (2) protection against extra trains will not be required. The time of regular trains must be cleared.

(*3*) "*Protecting against* (*No 1*) *or all regular trains.*"

Under (3) the Work extra can work upon the time of the train or trains named in the order, and must protect against such train or trains as prescribed by Rule D–99.

(*4*) "*Protecting against trains moving against the current of traffic on* ______ *track.*"

Under (4) protection must be given against trains which may be moving against the current of traffic on the track or tracks named.

---

### D-FORM J. HOLDING ORDER

Hold ______ at ______ .

EXAMPLES

(*1*) *Hold No 2 at Berlin.*
(*2*) *Hold all eastbound trains at Berlin.*

This order will be addressed to the operator and acknowledged in the usual manner. It must be respected by conductors and enginemen of trains thereby directed to be held as if addressed to them.

When a train has been so held it must not proceed until the order to hold is annulled, or an order given to the operator in the form:

"______ *may go.*"

D–Form J will only be used when necessary to hold trains until orders can be given, or in case of emergency.

---

### D-FORM K. ANNULLING A REGULAR TRAIN

(1) ______ of ______ is annulled ______ to ______.
(2) ______ due to leave ______ ______ is annulled ______ to ______.

EXAMPLES

(*1*) *No 1 of Feb 29th is annulled Alaska to Halifax.*
(*2*) *No 3 due to leave Naples Saturday Feb 29th is annulled Alaska to Halifax.*

The train annulled loses both right and class between the stations named and must not be restored under its original number between those stations.

---

### D-FORM L. ANNULLING AN ORDER

Order No ______ is annulled.

If an order which is to be annulled has not been delivered to a train, the annulling order will be addressed to the operator, who will destroy all copies of the order annulled but his own, and write on that:

*Annulled by order No ______.*

EXAMPLE

*Order No 10 is annulled.*

An order which has been annulled must not be reissued under its original number.

In the address of an order annulling another order, the train first named must be that to which right was given by the order annulled, and when the order is not transmitted simultaneously to all concerned, it must be first sent to the point at which that train is to receive it and the required response made, before the order is sent for other trains.

---

### D-FORM M. ANNULLING PART OF AN ORDER

That part of order No ______ reading ______ is annulled.

EXAMPLE

*That part of Order No 10 reading Extra 263 will pass No 1 at Sparta is annulled.*

In the address of an order annulling a part of an order, the train first named must be that to which right was given by the part annulled, and when the order is not transmitted simultaneously to all concerned, it must be first sent to the point at which that train is to receive it, and the required response made, before the order is sent for other trains.

---

### D-FORM P. SUPERSEDING AN ORDER OR A PART OF AN ORDER

This order will be given by adding to prescribed forms the words "instead of ______."

(1) ______ will pass ______ at ______ instead of ______.

(2) ______ will display signals for ______ ______ to ______ instead of ______.

EXAMPLES

(1) *No 1 will pass No 3 at Medina instead of Khartoum.*

(2) *No 1 will display signals for Eng 85 Astrakhan to Teheran instead of Cabul.*

An order which has been superseded must not be reissued under its original number.

---

**D-FORM R. PROVIDING FOR A MOVEMENT AGAINST THE CURRENT OF TRAFFIC**

____ has the right over opposing trains on ____ track ____ to ____.

EXAMPLE

(1) *No 1 has right over opposing trains on No 2* (*or eastward*) *track Mecca to Mirbat.*

A train must not be moved against the current of traffic until the track on which it is to run has been cleared of opposing trains.

Under this order the first named train must use the track specified between the two points named and has the right over opposing trains on that track between those points. Opposing trains must not leave the point last named until the first named train arrives.

An inferior train between the points named moving with the current of traffic in the same direction as the first named train must receive a copy of the order, and may then proceed on its schedule, or right.

This order may be modified as follows:

(2) After ____ arrives at ____ ____ has right over opposing trains on ____ track ____ to ____.

EXAMPLE

*After No 4 arrives at Mecca No 1 has right over opposing trains on No 2* (*or eastward*) *track Mecca to Mirbat.*

Under (2) the train to be moved against the current of traffic must not leave the first-named point until the arrival of the first-named train.

---

**D-FORM S. PROVIDING FOR THE USE OF A SECTION OF DOUBLE TRACK AS SINGLE TRACK**

____ track will be used as single track between ____ and ____.

If it is desired to limit the time for such use add (from ____ until ____).

EXAMPLE

*No 1* (*or westward*) *track will be used as single track between Mecca and Mirbat.*

Adding if desired

*from 1 p m until 3 p m*

Under this order all trains must use the track specified between the stations named and will be governed by rules for single track.

Trains running against the current of traffic on the track named must be clear of the track at the expiration of the time named, or protected as prescribed by Rule D–99.

# FORMS OF BLANKS FOR SINGLE AND DOUBLE TRACK

FORM—(A)

_______________ (NAME) _______________ COMPANY

## CLEARANCE CARD

Dover _______ 9:15 A. M. _______ March 25 _______ 19 02

Conductor and Engineman No. 12

I have no (further) orders for your train.

Signal is out for Extra 452

This does not interfere with or countermand any orders you may have received.

John Jones
Operator

Conductor and Engineman must each have a copy, and see that their train is correctly designated in the above form.

*(To be printed on yellow paper)*

## STANDARD TRAIN ORDER BLANK FOR 31 ORDER

### SPECIFICATIONS FOR TRAIN ORDER FORM AND BOOKS FOR OPERATORS FOR 31 ORDERS

Form as here shown. Blank space for order (4) inches with no lines. The mode of filling the blanks is indicated by small type.

Form ($6\frac{3}{4} \times 9\frac{1}{4}$) inches beyond perforated line. Book ($6\frac{3}{4} \times 10\frac{1}{2}$) inches. 300 leaves. Glued at top or side. Manila cover on face and stiff back.

Paper opaque, yellow, sized, and of such thickness as to admit of making (9) good manifold copies with stylus and double carbons.

To be used with double Carbon Paper ($6\frac{3}{4} \times 9$) inches, and a stiff tin, same size, corners rounded.

FORM 31 ______ (NAME) ______ COMPANY FORM 31

TRAIN ORDER No. 10

March 27 19 02

*To* ______ *At* ______

*X* ______ (Initials) ______ *Opr.;* ______ 1 45 A *M*

______

Conductor and Engineman must each have a copy of this order

*Repeated at* 2 20 A *M.*

| Conductor | Engineman | Train | Made | Time | Opr. |
|---|---|---|---|---|---|
| Jones | Brown | 45 | Complete | 2 20 a.m. | Black |
| | | | | | |
| | (Omit | | | | |
| | this column | | | | |
| | where | | | | |
| | Engineman | | | | |
| | is not | | | | |
| | required | | | | |
| | to sign.) | | | | |

## STANDARD TRAIN ORDER BLANK FOR 19 ORDER

### SPECIFICATIONS FOR TRAIN ORDER FORM AND BOOKS FOR OPERATORS FOR 19 ORDERS

Form as here shown. Blank space for order (4) inches with no lines. The mode of filling the blanks is indicated by small type.

Form ($6\frac{3}{4} \times 6$) inches beyond perforated line. Book ($6\frac{3}{4} \times 7\frac{1}{2}$) inches.

300 leaves. Glued at top or side. Manila cover on face and stiff back.

Paper opaque, green, sized, and of such thickness as to admit of making (9) good manifold copies with stylus and double carbons.

To be used with double Carbon Paper ($6\frac{3}{4} \times 7$) inches, and a stiff tin, same size, corners rounded.

FORM 19 FORM 19

(NAME) **COMPANY**

TRAIN ORDER No. 10

March 27 *19* 02

*To* *At*

*X* (Initials) *Opr.;* 1 45 A *M*

Conductor and Engineman must each have a copy of this order

*Made* Complete *time* 2 16 P *M.* Black *Opr.*

# CAR LIGHTING

## INTRODUCTION

**1.** Among the many advances that have been made in railroad equipment during the last few years, one of the most notable has been in connection with the matter of **car lighting.** The ordinary oil lamp was never very satisfactory, its objectionable odor and heat and its liability to explosion emphasizing the necessity of producing something better. Hence, although on the majority of cars oil is still used, on the better class of trains the railroad companies have for some years been adopting **gas,** and, in some cases, **electric light.**

The first step in the direction of improvement was the use of ordinary coal gas, stored at pressure and fed out gradually, but the illuminating power of this gas was impaired by compression. Now, however, **oil gas** is being widely used instead; it is stored at a high pressure and passes through a pressure regulator on its way to the lamps, thus having its pressure reduced to a proper degree. This gas is, in this country, made from a high-grade petroleum distillate, and in Europe from what is called *shale oil.* It has the property of enduring considerable compression without any loss in illuminating power, an advantage not shared by ordinary coal or city gas. This method of lighting by oil gas is safe, clean, and economical; the light itself is soft, and at the same time brilliant, and, being evenly distributed, renders reading in any part of the car a pleasure.

# THE PINTSCH SYSTEM

## GENERAL DESCRIPTION

**2.** In the **Pintsch system,** the lamps are supplied with gas from storage tanks or holders carried underneath the car. The gas is stored therein at a pressure of about 150 pounds per square inch, and on its way to the lamps passes through a regulator that automatically reduces it to a pressure of about 1 ounce per square inch, irrespective of the actual pressure in the tanks. The supply of gas carried on a car varies according to the service it is engaged in, but, on an average, a supply of gas for from 2 to 4 nights' service is carried.

## GENERAL EQUIPMENT

**3.** The general arrangement of the apparatus is shown in Fig. 1, wherein $H$ is the *gas holder* in which the gas is stored under pressure and from which it passes through pipe $P''$ to the *pressure regulator* $R$. Thence it goes through the pipes $p\,p$ to the piping on the roof of the car, being distributed thence to the various lamps.

When the holder $H$ is about to be charged, a *hose* connecting with the charging lines from the gas station is attached to a *filling valve* $V$, one of these valves being located on each side of the car, for convenience. Pipes $P$ and $P'$ lead from the filling valves to the holder. When the charging is being effected through the valve on the far side of the car, as viewed in the figure, the gas comes through pipe $P'$, and on through $P''$ into the holder. Afterwards, gas feeds back to the regulator through pipe $P''$. A *pressure gauge* $G$ is piped to the **T**-flange union $u$. This gauge serves two purposes: (1) to show what the pressure is in the holder and in the pipes $P$, $P'$, and $P''$ (these, by the way, being spoken

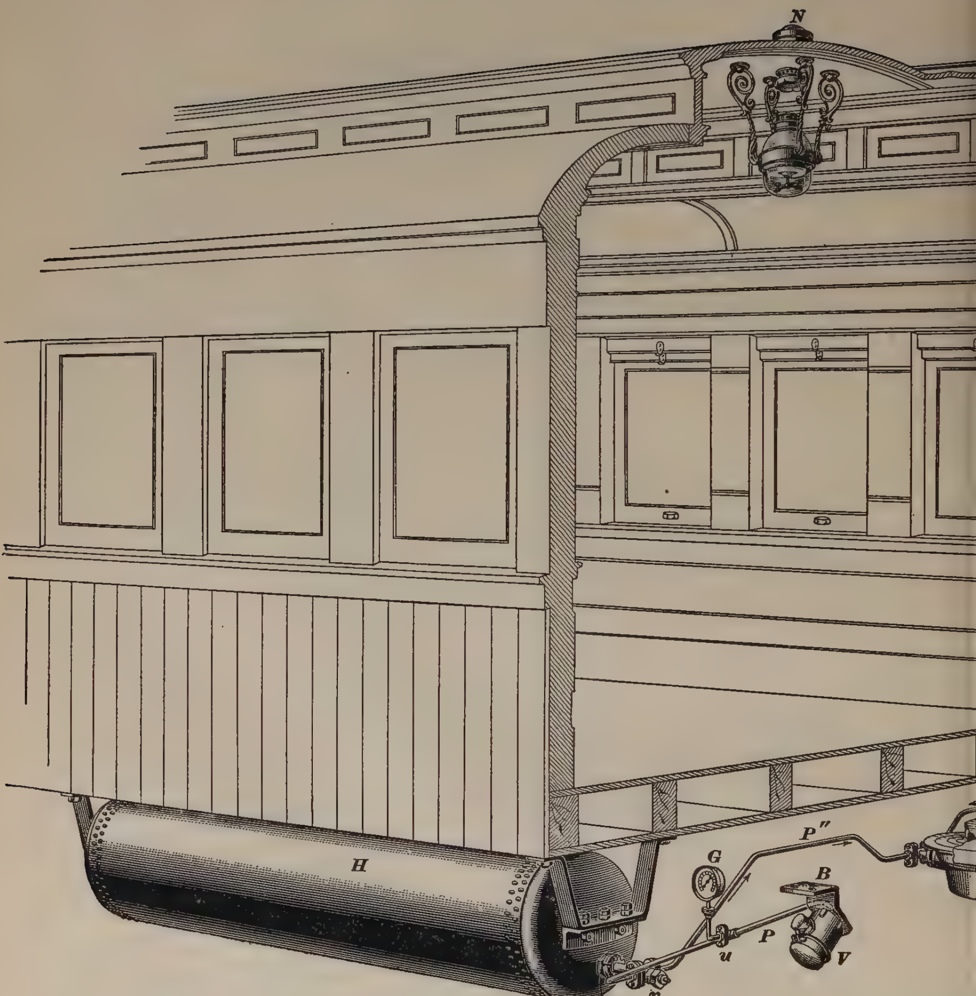
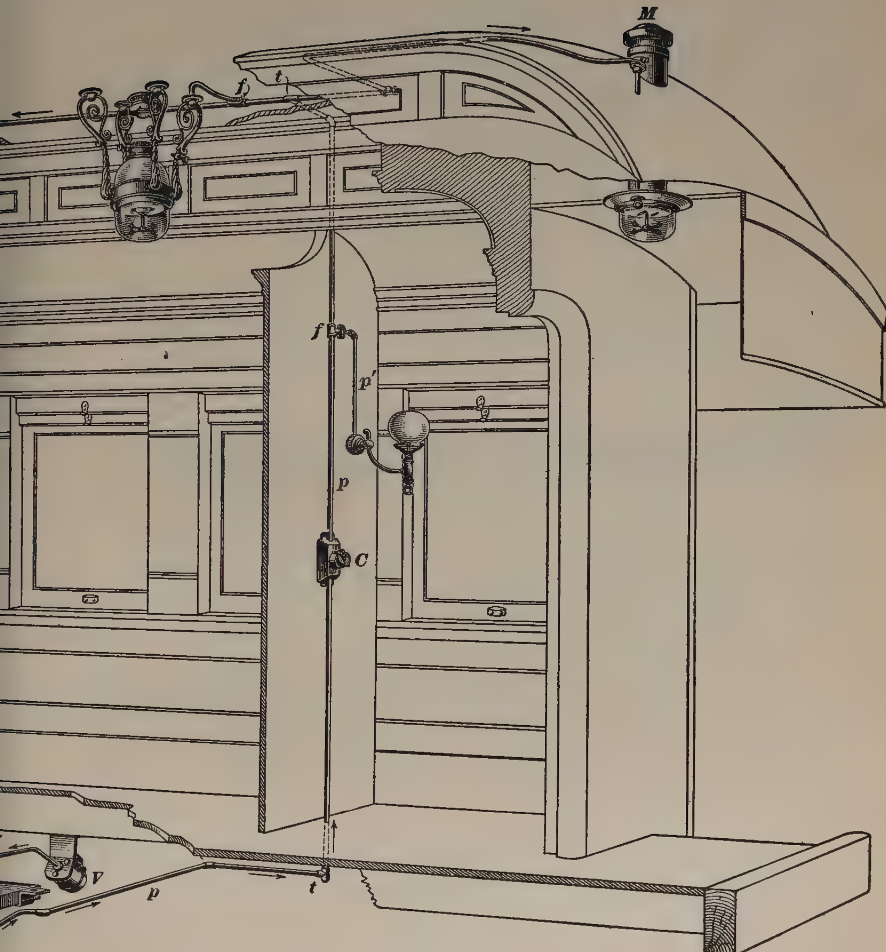



FIG. 1




§ 24

of as the *high-pressure* pipes); and (2) to show how much gas is consumed in a given period.

About 5 feet above the car floor is placed the *main cock C*, boxed in so as not to be tampered with. By means of this cock the brakeman can control the flow of gas to the lamps.

Above each lamp in the roof of the car is fixed a *ventilator*, that for the vestibule lamp being shown at *M*, and that for one of the aisle lamps, at *N*.

## GAS HOLDER

**4.** An illustration of the **gas holder,** also called a *receiver*, is given in Fig. 2. These holders are cylindrical in form

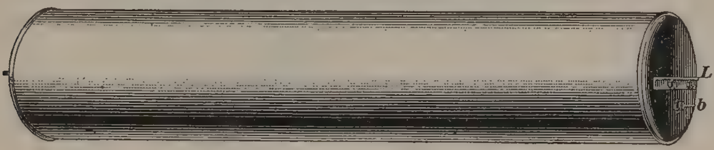



FIG. 2

and have dished ends for the sake of greater strength; a flat end would bulge out under pressure. The ends of the holders

**TABLE I**

**SIZES OF GAS HOLDERS**

| Diameter Inches | Length | | Capacity Cubic Feet |
|---|---|---|---|
| | Feet | Inches | |
| 16.5 | 6 | 1 | 8.8 |
| 18.5 | 6 | 1 | 11.0 |
| 20.5 | 6 | 1 | 13.5 |
| 20.5 | 7 | 10 | 17.5 |
| 20.5 | 8 | 6 | 19.0 |
| 20.5 | 9 | 6 | 21.3 |

are either riveted and bolted on, or, as in Fig. 2, brazed. A piece of angle iron *L* is bolted on to each end, and is itself

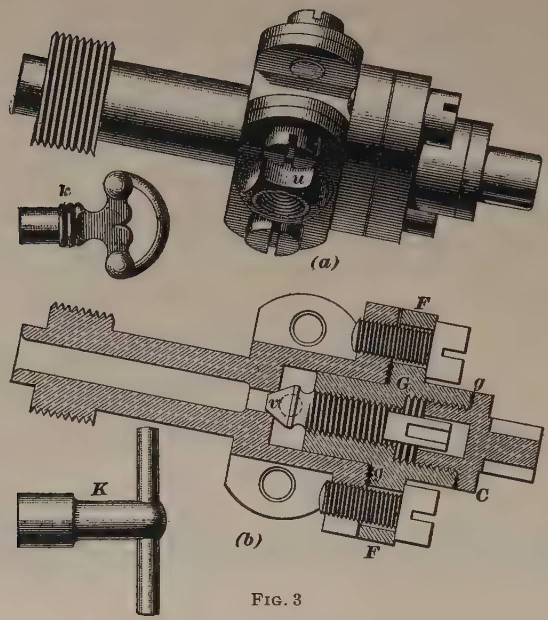



FIG. 3

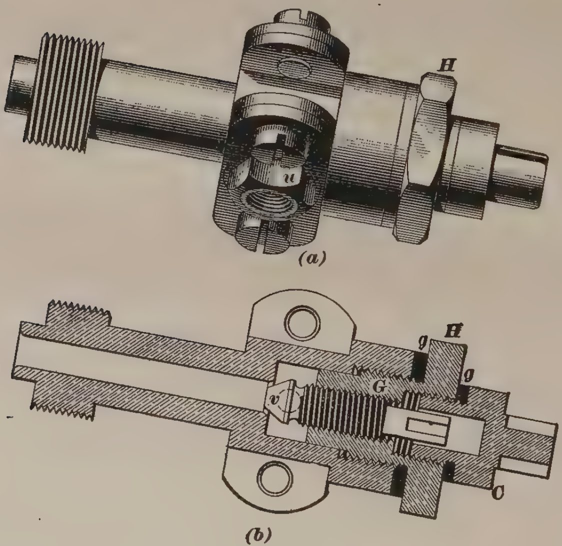



FIG. 4

bolted to the hanger that is attached to the car frame. At one end is the *outlet bushing* $b$, to which is attached a valve known as the *holder valve.*

These holders vary in capacity according to the service for which the car is intended. Table I gives the sizes used on railroad cars.

---

### HOLDER VALVE

**5.** There are two types of **holder valve** in present use, the "old style" and the "new style." The old style of valve is shown in Fig. 3, the new style, in Fig. 4, ($a$) in each case being an elevation, and ($b$) a section. The new style differs from the old in that the flanges $F$, $F$ on the gland $G$ are dispensed with, the gland being made hexagonal at $H$ and tightened up by means of a wrench, instead of using bolts, as in the old type.

The valve $v$ controls the flow of gas into or out of the holder. To open or shut this valve, the cap $C$ has to be taken off by means of key $K$, and the valve turned by key $k$. $g$, $g$ are gaskets to make the various joints gas-tight. The dotted circle behind the valve $v$ is the passage leading to the filler, the pipe connection being made by the union $u$ shown in the elevation. There is one of these connections on each side of the valve, as seen in Fig. 1. The connection to the holder is made by means of the outlet bushing $b$, Fig. 2.

---

### REGULATOR

**6.** In Fig. 5 is given an outside view of the **regulator** used in the Pintsch system, $I$ being the inlet and $O$, the outlet. The *inlet bushing*, shown separately at ($a$), is screwed into the regulator casting at $I$, the connection with the high-pressure piping being made by means of the fitting $F$ shown in Fig. 6. The flange $f$, Fig. 6, is screwed on to the fitting $F$, and then this flange and the flange $f'$, Fig. 5, are bolted together by three bolts. Connection is made at $O$ with the low-pressure piping leading to the various lamps.

These regulators are not shown in section, as they are supposed to be put up as received from the makers, and not

to be opened subsequently. There is a flexible diaphragm in the regulator that, when acted on by the pressure of the gas in the low-pressure piping, opens or closes the regu-

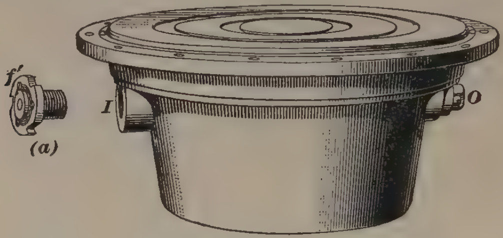



FIG. 5

lating valve that admits gas from the storage tank. In the older type of regulator, there is a loose bushing in the center of the flange $f'$, as seen in Fig. 5 ($a$); its duty is to hold the

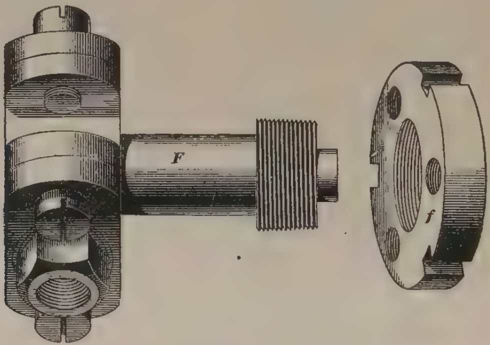



FIG. 6

strainer of the inlet bushing in position, as well as to make the joint gas-tight. In the later regulators this bushing is not used.

---

## FILLING VALVE

**7.** The **filling valve** used on the cars is shown in Fig. 7, a sectional view of the valve and its cover being given. Gas is admitted from the main supply pipe through a hose connection made at $A$. The gas passes along the passage up through $b$, and if the valve $f$ is off its

seat, as shown in the figure, the gas passes down through *c* and along passage *d* into the pipe leading to the holder. The valve *f* is raised or lowered by turning the stem *s*. When the valve is raised off its seat to admit gas, it is screwed up against the bonnet *e e*, the packing ring *m* making the joint gas-tight. The valve carrier *g*, which moves up

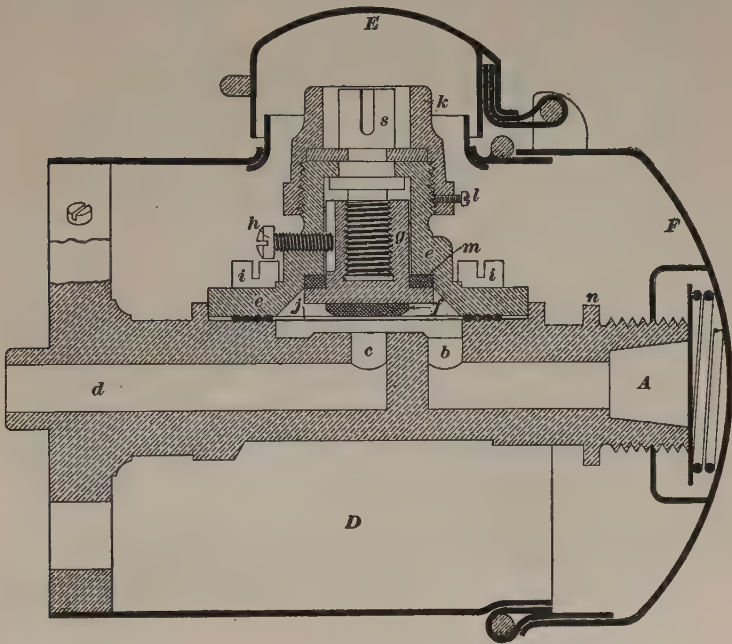



FIG. 7

and down as the stem *s* is rotated, is prevented from turning around by the screw *h*, which engages in a slot cut in *g*. The bonnet *e e* is bolted to the body of the filling valve by the screws *i*, the gasket *j* making the joint. The gland *k* is locked in position by the screw *l*. *D* is the cover enclosing the whole, *E* being the key cap and *F* the cover cap.

## PRESSURE GAUGE

**8.** The various **pressure gauges** used are shown in Fig. 8. (*a*) is the one shown in Fig. 1; (*b*) is similar, except for the method of attachment; (*c*) is the kind used by the car filler. In gauge (*a*), the type shown in Fig. 1 and also in Fig. 18, the pipe *P* leads to the **T**-flange union *u* in the piping between the filling valve and holder. The construction of the gauges is the same in each case. They are graduated to atmospheres instead of pounds, as in the case of steam gauges; they can be had, however, graduated to

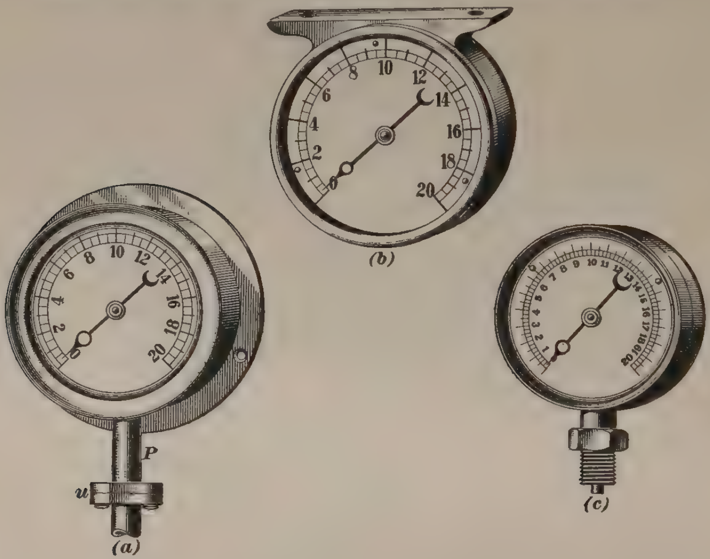



FIG. 8

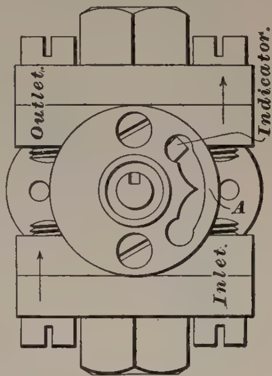
both atmospheres and pounds. *Atmospheric pressure* is about 14.7 pounds per square inch (rather less than $14\frac{3}{4}$ pounds), so that a "pressure of 8 atmospheres" is $14.7 \times 8 = 117.6$ pounds; 10 atmospheres is $14.7 \times 10 = 147$ pounds; 12 atmospheres is $14.7 \times 12 = 176.4$ pounds, and so on.

These gauges must be accurate, as they are used to measure the amount of gas in the holders; also, the amount supplied when the holders are refilled.

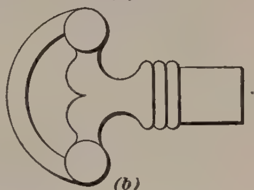
## MAIN COCK

**9.** In Fig. 9 ($a$) is shown an outside view of the fitting known as the **main cock,** one of which is provided on each car. Its position in the car was shown in Fig. 1 at $C$ (see also Fig. 22). This cock is boxed in and is provided with a key ($b$), by which the brakeman can turn the gas on and off from that particular car. On postal cars, the cock shown at $c$ is used, the handle being fixed, not detachable.

**10. Double Pipe Line.**—It is sometimes advisable, in the case of private cars and also sleeping and dining cars, to run two lines of roof pipes, using two main cocks (see dotted parts $C'$, $C'$ in Fig. 22). The lamps in the main body of the car, and also those in the smoking and dining rooms, are connected to one of the pipe lines, while the passageway and toilet brackets and the end lamps and vestibule lamps are connected to the other line. This enables the brakeman, by means of the main cock, to control the lamps on one line independent of the lamps on the other line.



(a)


(b)

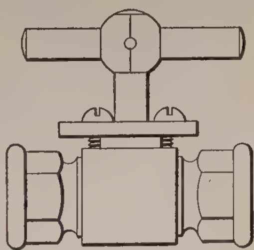

(c)

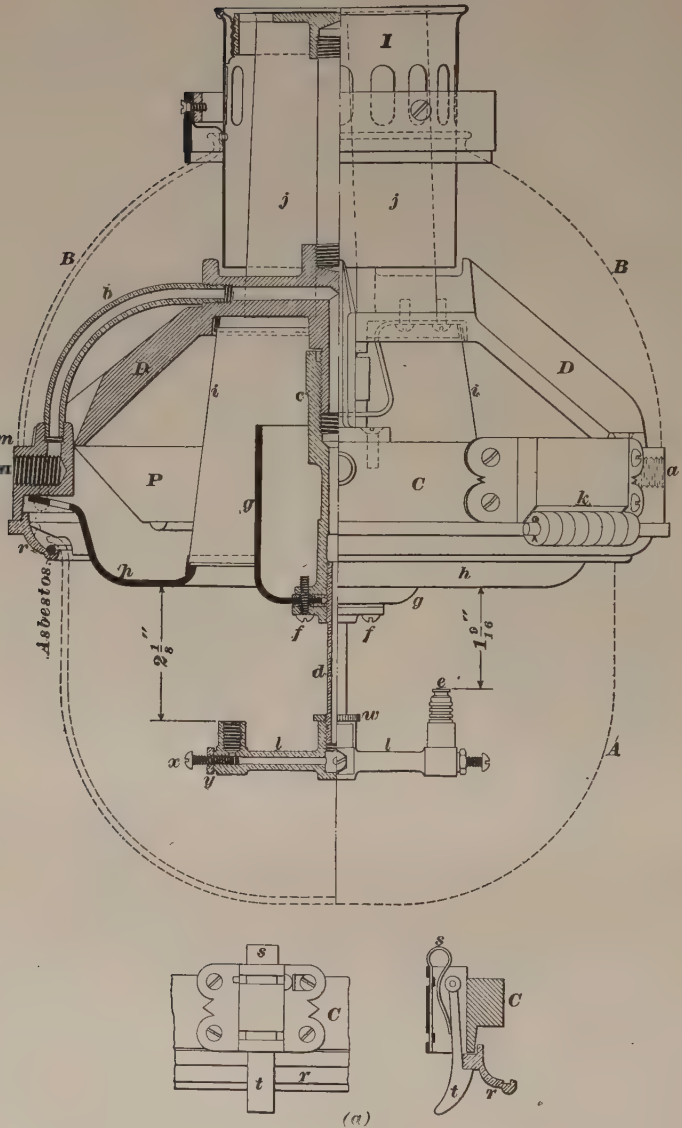
FIG. 9

## LAMPS

### DESCRIPTION OF VARIOUS TYPES

**11.** Various designs of **lamps** are used in this system, as illustrated further on, but the *lamp body* is practically the same in each case; it is illustrated in Fig. 10, which is a half sectional view.

The glass *globe*, or *bowl*, is marked $A A$; $B B$ is the opalescent, or opal, *dome*. Gas from the supply pipe in the



I
j
j
B
B
b
D
D
i
c
i
m
n
P
C
a
g
k
r
p
h
g
Asbestos
f
f
$2\frac{1}{8}''$
$1\frac{9}{16}''$
d
e
w
l
l
x
y
A
s
C
t
r
s
C
t
r
(a)


FIG. 10

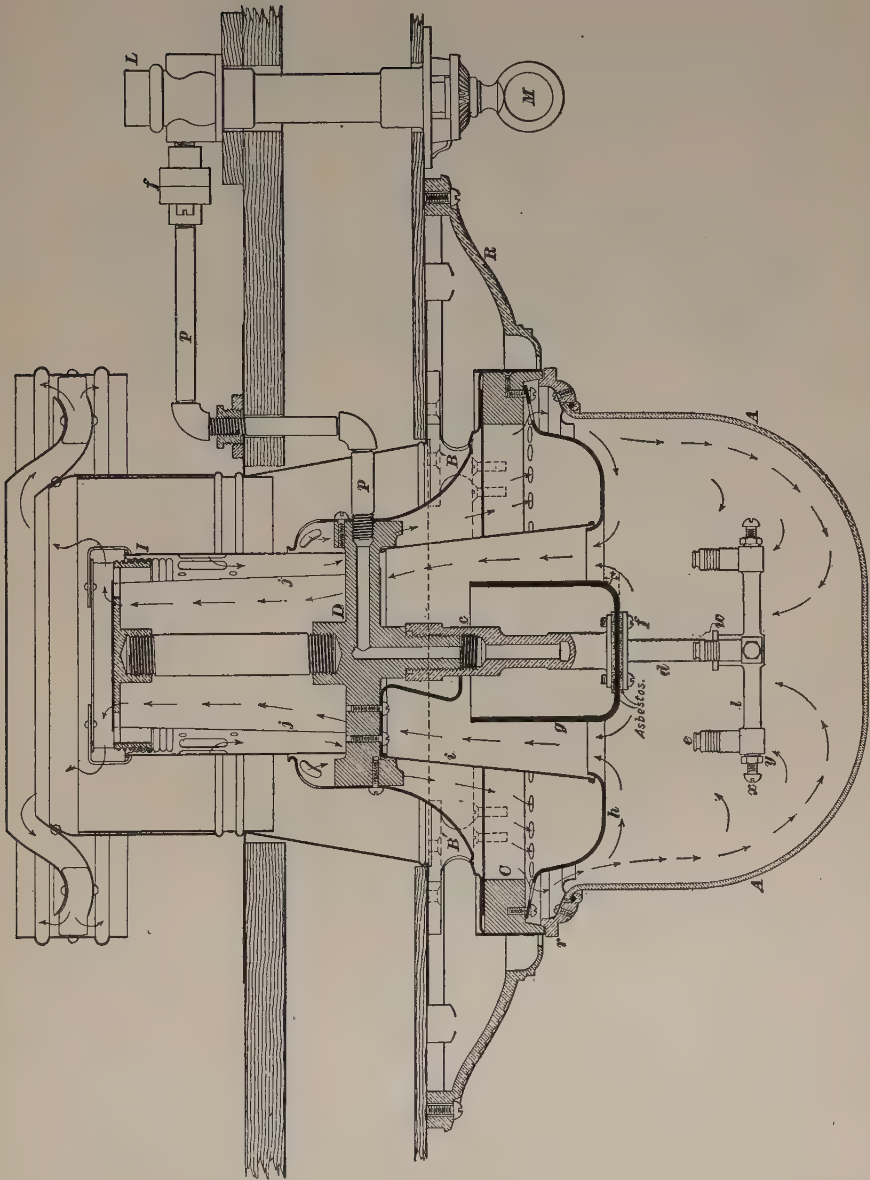



FIG. 11

roof of the car passes down one of the arms supporting the lamp (see $E'$, Fig. 12) and passes into the ring $G$ at $a$, thence going up through tube $b$ and down the pillar $c$ and so on to the *cluster stem* $d$, *cluster* $l\,l$, and *burners* $e$. The *cup*

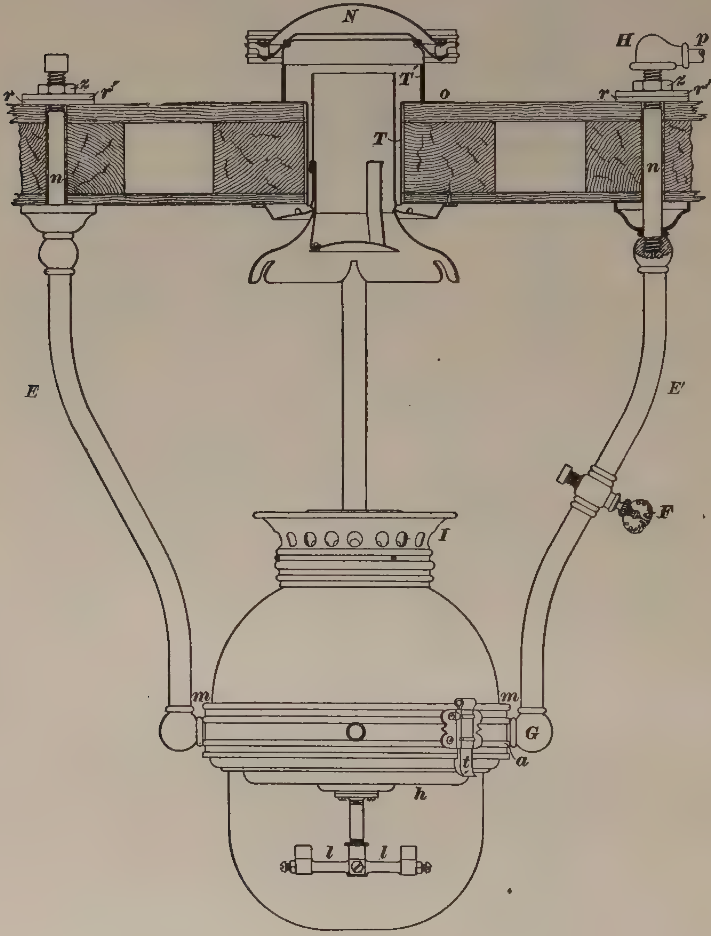



Fig. 12

*reflector* $g\,g$ is bolted to the pillar $c$ by screws $f$, asbestos rings being placed above and below the opening in reflector; $h\,h$ is the *ring reflector;* $i\,i$ is a *mica chimney*, up which the hot air

and gases pass, and thence through the *flues* $j$, $j$. $D$ $D$ is the spider that, with the ring $C$, forms the framework of the lamp, the hinge being at $k$. At $(a)$ are shown two views of the spring catch for locking the glass bowl $A$ to the iron ring $C$; $t$ is the catch, $s$ is its spring, $C$ is part of the iron ring, and $r$ is the bezel or ring for the bowl. The glass bowl is made air-tight on the rim $r$ by means of an asbestos wick.

Two important dimensions have been noted in the illustration; namely, the distance between the bottom of ring reflector and the top of cluster where the burner screws in; also, the distance between reflector and top of burner when

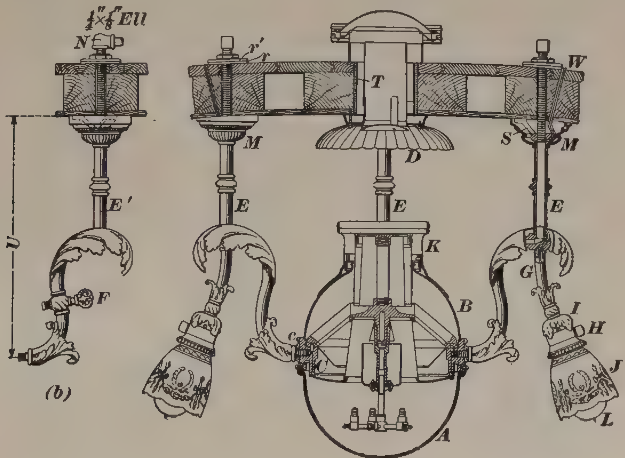



FIG. 13

in position. Another important dimension is the distance between faces of ring and cup reflectors; it should be $\frac{1}{4}$ inch, as shown in the lamp next described.

**12.** Fig. 11 illustrates a type of lamp supported from the roof by means of the brackets $B'$. The various parts are lettered to correspond with those in Fig. 10. The descending arrows show the course taken by the incoming air, while the ascending arrows show the path of the escaping hot air and gases after leaving the flame and bowl.

**13.** Fig. 13 shows a composite lamp, being arranged to use both Pintsch gas and electricity, there being two electric lamps provided in case the latter light is desired.

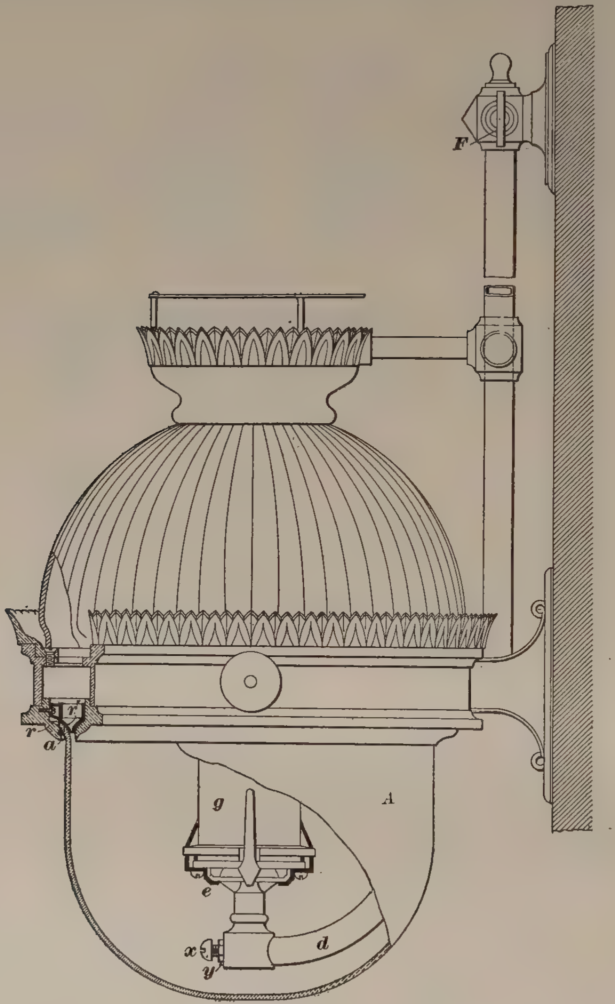



FIG. 14

In view (*a*) is shown a section of the lamp as made transversely to the car. (*b*) is a view at right angles to the

first, showing the gas arm $E'$. This arm is not seen in view ($a$), it being in the front part of the lamp, and therefore removed in order to show the latter in section. In the illustrations, $A$ is the glass bowl and $B$ the glass dome. $C$ is the cast-iron body ring, and $c$ is an outside ring. $D$ is the ventilating bell. $E$ and $E'$ are the lamp arms, the three marked $E$ being plain arms and $E'$ the gas-way arm—the lamp cock in this latter arm being marked $F$. $G$ is the extension arm carrying the electric lamp $L$. $M$ is the ceiling plate; $N$ is an

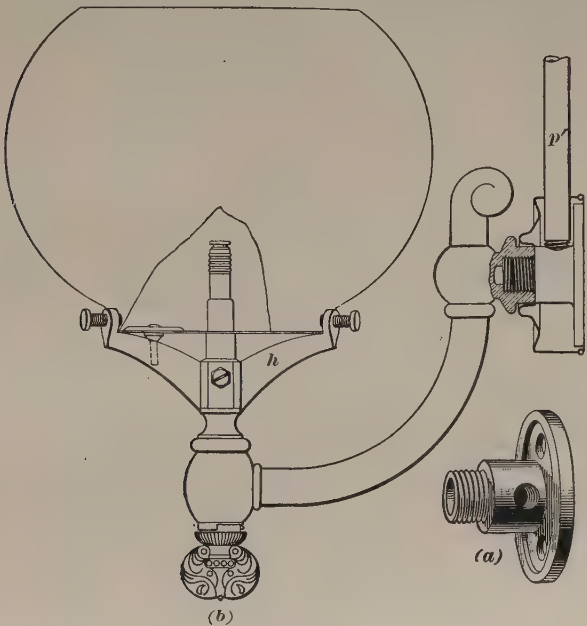



FIG. 15

L piece connecting the roof gas pipe with the gas tube leading to the lamp. $T$ is the ceiling thimble, covered with asbestos; $r$ and $r'$ are special rubber and iron washers, respectively; $S$ is the arm spider, and $W$, the electric wires.

**14.** Fig. 14 is an illustration of an **Argand bracket lamp**, part of the bowl $A$ being shown broken away, so as to disclose the chimney, burner, etc. in the interior of the

lamp. *F* is the thumbscrew by which gas is turned on to the lamp; *d* is the gas tube conveying the gas to the burner *e*; *g* is the chimney; *r* is the globe ring or bezel; *a* is the asbestos wick to make the bowl fit air-tight against the ring *r*; *r'* is the globe retaining ring.

A different form of side bracket is shown in Fig. 15.

---

### ACTION OF THE LAMPS

**15.** All center lamps (various forms of which are shown in Figs. 10, 11, 12, and 13) are so arranged that the incoming air is heated considerably before coming in contact with the flame, the result being increased whiteness and steadiness of light. As seen in Fig. 10, air is admitted through openings in the chimney *I*; passing downwards, it comes in contact with the side of flue *j* and so becomes heated. It then passes into the space between the dome *B* and the mica chimney *i*, where it is heated still more, the diaphragm *P* deflecting the air toward the chimney. It passes from the space between *i* and *h* out of the holes in the outer edge of *h* and so on into the bowl *A*. The tortuous course that the air thus takes serves to protect the flame from any irregular drafts. The gases of combustion thrown off by the flames pass through the space between *g* and *i*, up through the flue *j*, and out of the crown. The arrows in Fig. 11 show the path pursued by the incoming and outgoing air.

In the lamp shown in Fig. 16, the gases pass out through the flues *Q* and *S*. In the vestibule lamps, shown in Fig. 17, the air is admitted through the inlets *v*, *v* in the ventilating chimney, passing thence downwards inside the space *O*, *O* and then out through the holes in the body casting *z z* and so down to the flames. The gases of combustion pass up through the flue *j*, past the sheet-iron deflecting plate *D*, on into the inner chimney *I*, and so on to the outer air. Any air that may come in, more than is required for combustion of the gas, passes off into chimney *I*, through the space *a* between it and the flue *j*.

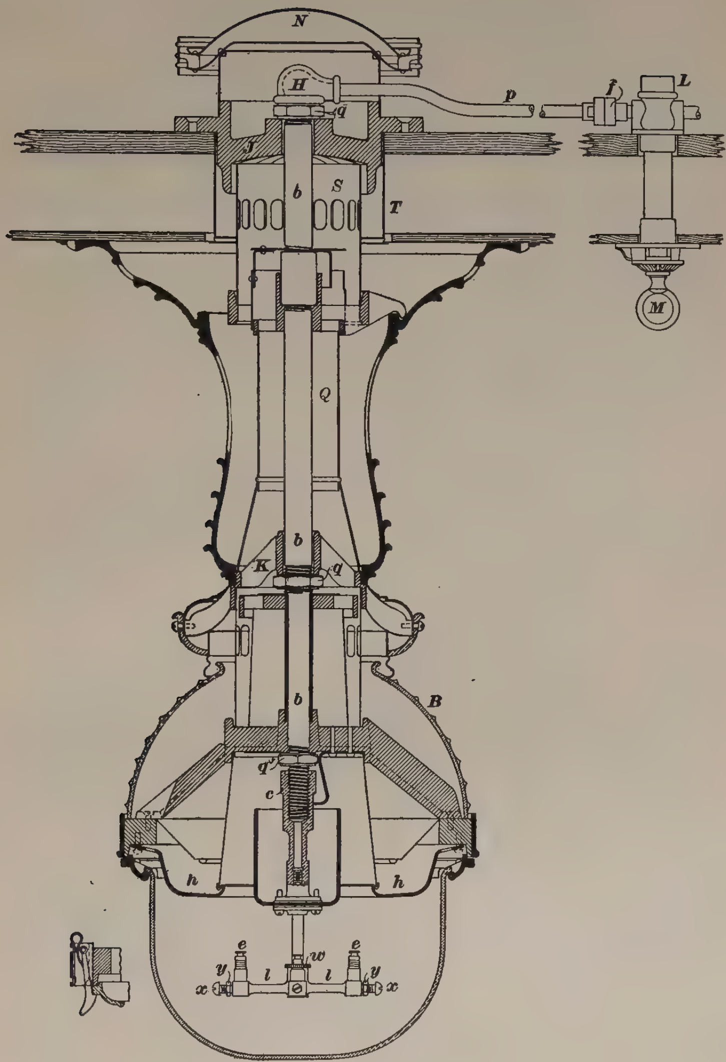
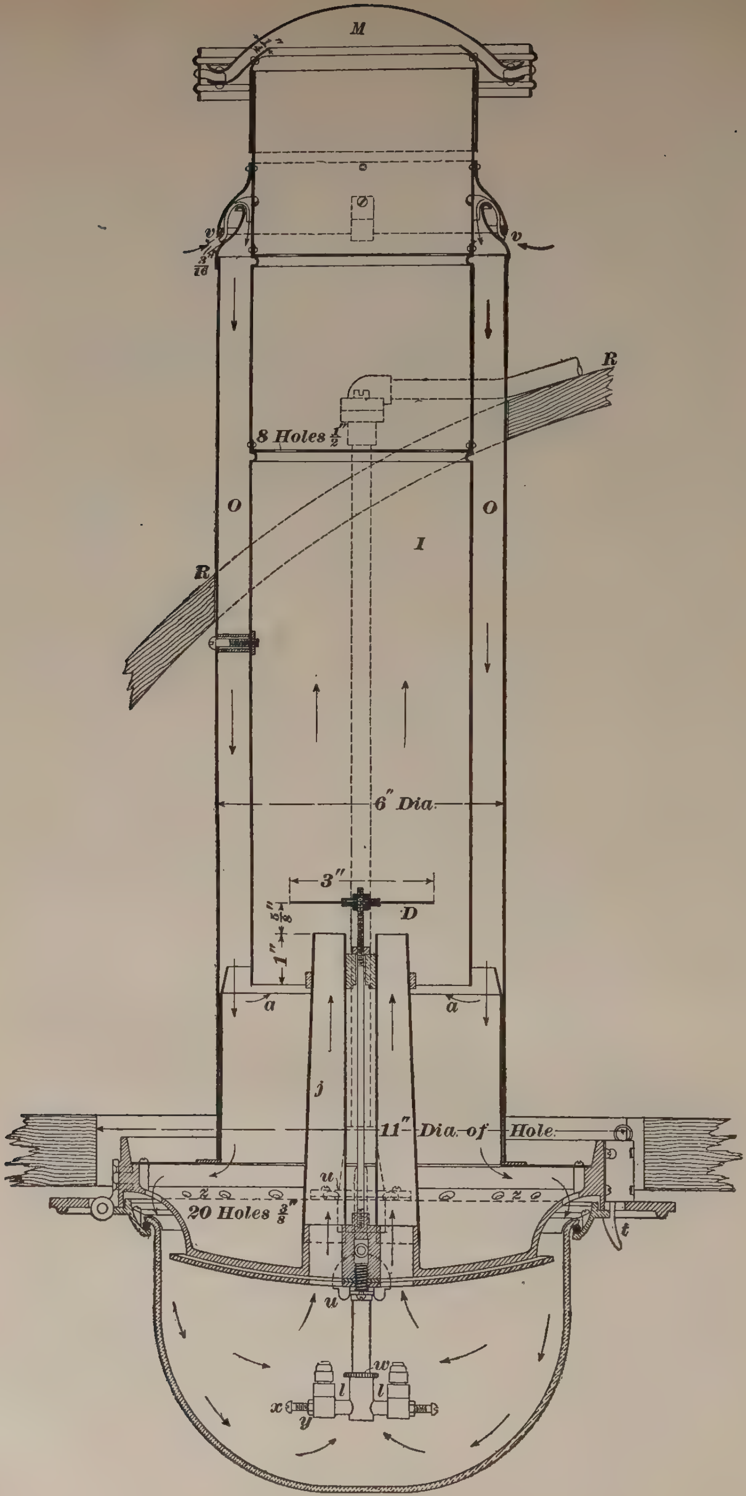



Fig. 16



M
v
v
3/16
R
R
8 Holes 1/2"
O
O
I
6" Dia.
3"
D
5/8"
1"
a
a
j
11" Dia. of Hole.
u
20 Holes 3/8"
t
u
w
l
l
x
y


FIG. 17

## APPLICATION OF EQUIPMENT

### HOLDERS

**16. Arrangement.**—Cars are fitted with one, two, or sometimes three holders in order to carry such a supply as circumstances demand. Fig. 18 and Fig. 19 (*a*) show the arrangement of a single holder, as adopted in Fig. 1. In Fig. 18, (*a*) is a plan view and (*b*) a side view; Fig. 19 (*a*) is an end view. When a second holder is used on one side of the car, it is arranged as shown in coarse dotted lines in Fig. 18 (*a*), and marked $H'$. Its position, as seen from the end of the car, is shown in Fig. 19 (*b*), where it is also marked $H'$. When two holders are used, one at each side of the car, they are arranged as shown in full lines in Fig. 19 (*b*); or three may be used, as also shown.

**17. Method of Attachment.**—Referring to Fig. 18, $H$ is the holder, carried from the car framing by the hanger $h$, which bolts on to the car sills by lagscrews $s$, and to the angle iron on the holder by bolts $t$.

### HOLDER VALVES

**18.** The holder valve, Fig. 20, is connected to the holder in the following manner: The flange $f$ is first screwed on to the inlet bushing $b$ until the bushing projects through the flange about $\frac{1}{16}$ inch, as shown. Next screw the flange $f'$ on to the end of the holder valve until there is about a $\frac{1}{16}$-inch projection there also. Then put a gasket in, as at $g$, and screw the two flanges together by means of the screws $s, s$, taking care that the flanges are pulled up squarely so that the gasket will be compressed evenly and will not leak.

### HIGH-PRESSURE PIPING

**19. Preparing the Pipes.**—All bends are to be made cold; no elbows or **T**'s to be used. All pipes carrying the compressed gas, $P$, $P'$, and $P''$, Figs. 1 and 18, are to be $\frac{1}{4}$ inch,

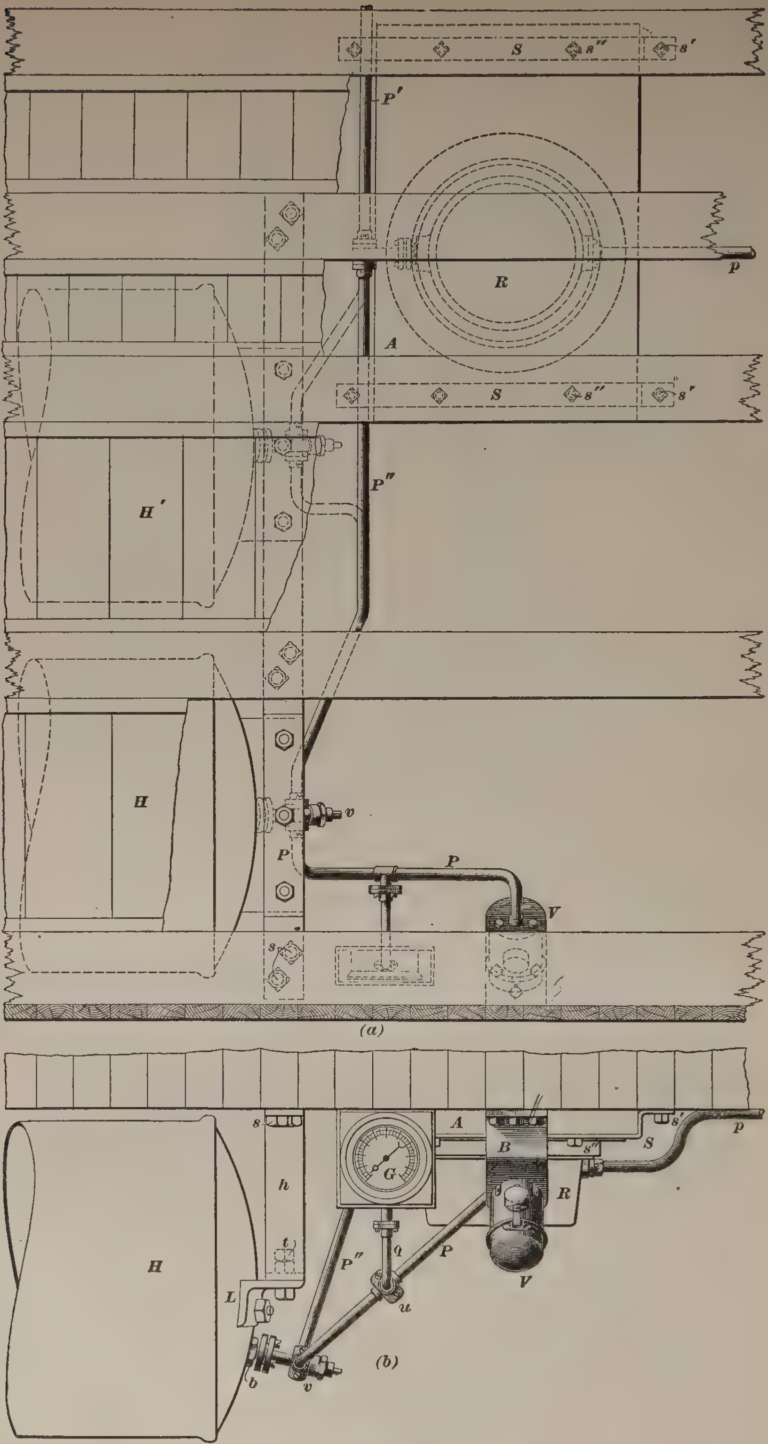



FIG. 18

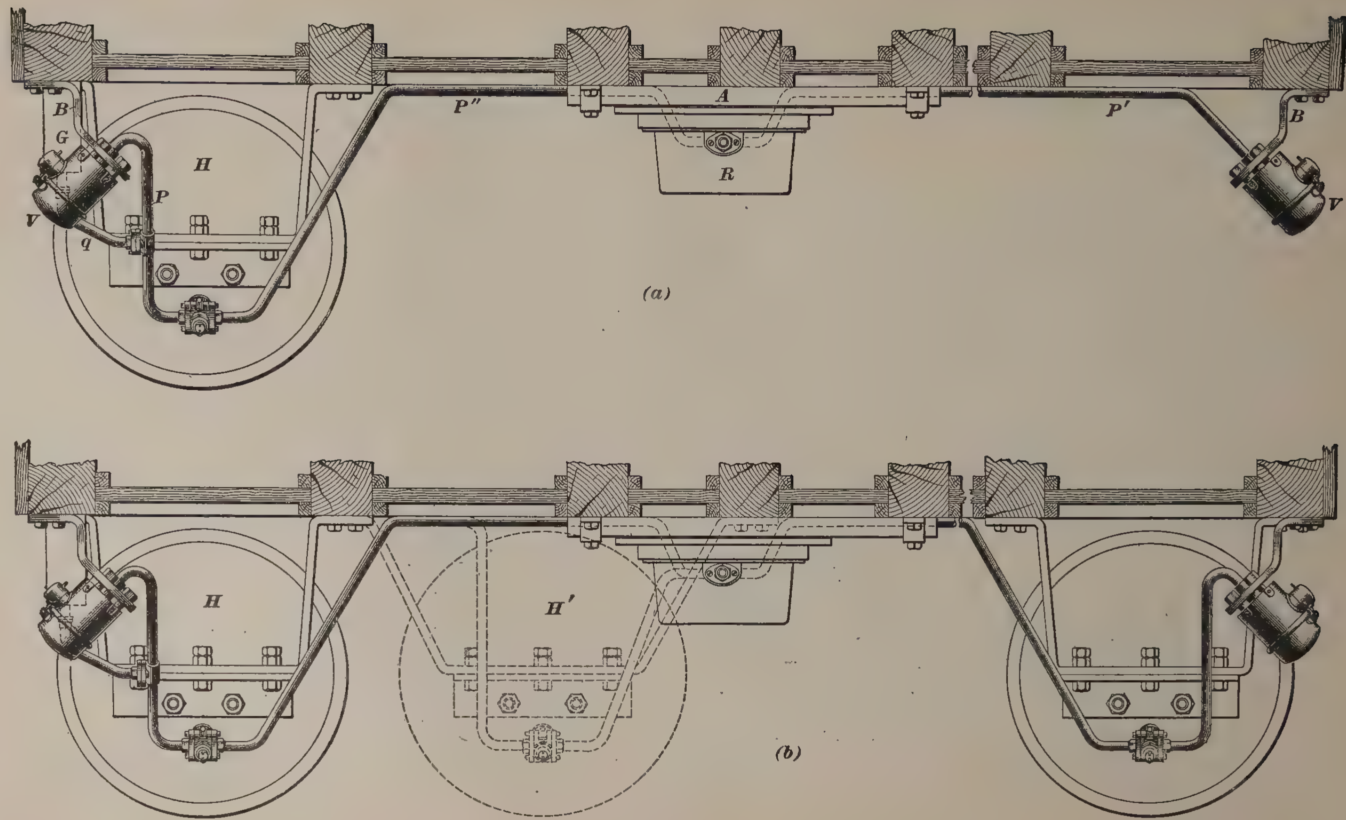



Fig. 19

extra strong, with the exception of the gauge pipe *q*, which is to be $\frac{1}{8}$ inch, extra strong. These constitute the **high-pressure piping.**

As far as practicable, all pipes should be set to drain to the holder valves *v*, Fig. 18. The gauge pipe must drain to the union *u*, Fig. 18 (*b*). Having bent all the pipes to their proper positions, proceed to screw on the flanges, first tinning the threads. See that the flanges "face" properly

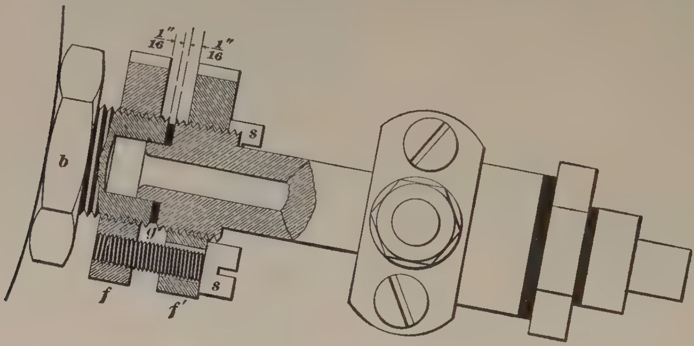



FIG. 20

before connecting up. When all the piping has been fitted up fairly in place, take it down again and solder around the flanges. The pipe *P*, Fig. 21, must be passed through the bracket *B* before the connection *C* is soldered on. Remove all burrs from the ends of the pipes and blow out all scale and dirt from inside the pipes, first jarring the latter well to loosen up the dirt, etc.

**20. Fixing Up the Pipes.**—Lead gaskets are used in all the joints (both in the pipe joints and also in those between holder valve and holder inlet at *g*, Fig. 20), and also in between flanges *f* and *f'* of the regulator connection, Figs. 5 and 6. Before screwing the filling valve to its bracket, the cover *D*, Fig. 21, must be taken off. To do this, remove the screws *s*, open the cover at the end, and rap with a piece of wood on the end *A* of the valve; the cover will then come off without taking the valve apart. Put a lead washer in at *g* and then place the end *d* of the

valve into the connection piece $C$ and bolt up with three $1\frac{3}{4}'' \times \frac{1}{2}''$ bolts. Put the two upper bolts $t$ in from the back, and the lower one $t'$ in from the front, as shown by the

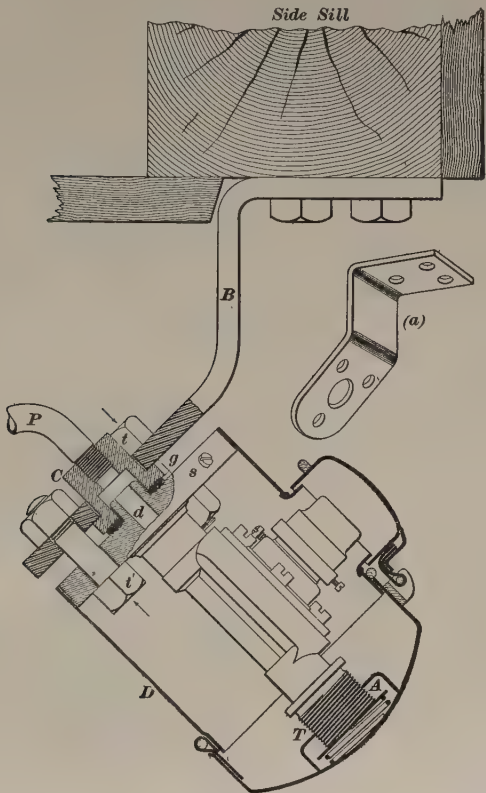



FIG. 21

arrows. By doing this, one is able to replace the valve at any time when the bolts are in place.

---

### LOW-PRESSURE PIPING

**21. Preparing the Pipes.**—The gas under low pressure is carried from the outlet of regulator to the roof of the car by the $\frac{1}{2}$-inch piping $pp$, shown in Fig. 1. The joints of this **low-pressure piping** are not soldered, but

merely made tight with lead paint. A **T** and plug are used for making the upward turn at *t*. At a point *C* about 5 feet above the floor *F*, Fig. 22, is placed the main cock, closed in with the cover shown in Fig. 23. This cock is so located that its *indicator* and the letter *A* are on the right-hand side, as shown in Fig. 9. At the point *r* where the pipe passes through the roof, Fig. 22, the pipe should be tinned before being put up permanently, and then soldered to the tin roof when in place. The connection between the vertical pipe *p* and the cross-pipe leading to the main roof pipe is made by means of the **T** and plug shown at *t*.

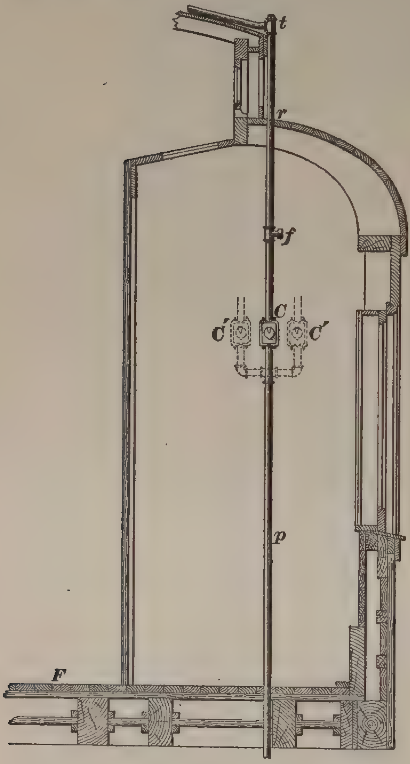



FIG. 22

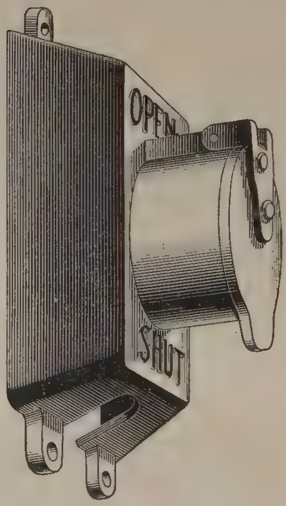



FIG. 23

It is sometimes thought desirable to have two lines of piping on the roof, in which case two main cocks, arranged as shown dotted at *C′*, *C′*, replace the single cock shown in full lines at *C*, Fig. 22.

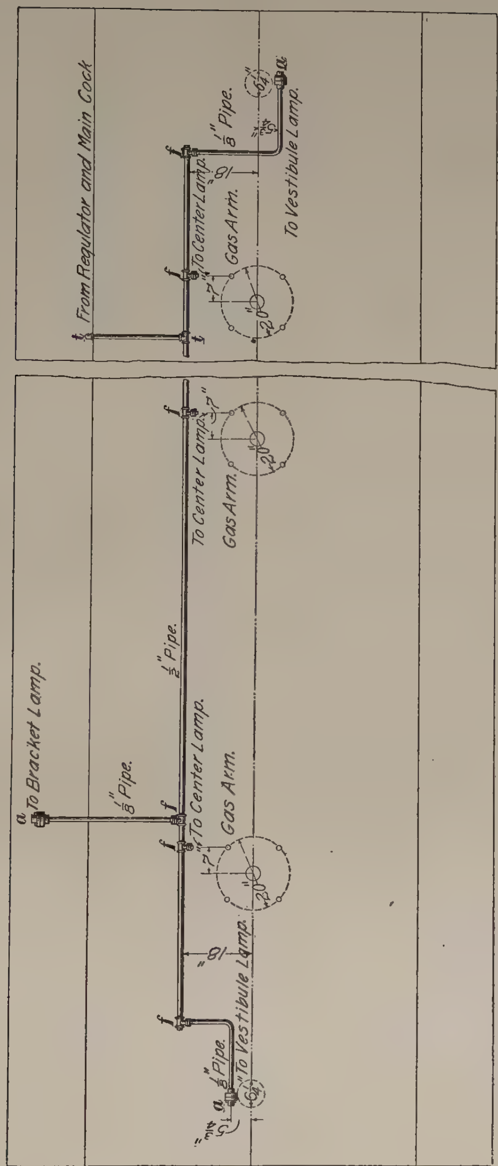

From Regulator and Main Cock
To Center Lamp.
Gas Arm.
1/8" Pipe.
To Vestibule Lamp.
1/2" Pipe.
To Bracket Lamp.
To Center Lamp.
Gas Arm.
To Center Lamp.
Gas Arm.
1/8" Pipe.
To Vestibule Lamp.

FIG 24

**22. Roof Piping.**—Fig. 24 is a plan of the roof, showing the piping. The pipe is carried along the roof about 18 inches from the center line. Flange **T**'s *f* are placed in this pipe line wherever required for the lamps; angle flanges *a* lead down from the $\frac{1}{8}$-inch pipe to the bracket and vestibule lamps. This piping should be laid on hardwood blocks about $\frac{1}{4}$ inch thick, spaced 4 feet apart, everything being secured in place by tinned-iron straps, shown in Fig. 25, using 1-inch wood screws, passing through both strap and wood into the roof. A little thick paint should be put around each block so that no water may soak past the screw holes in the roof.

Fig. 25

When vestibule lamps are used, it will be found advantageous to carry the roof pipe at the end of the car, in the manner shown in Fig. 24, so as to facilitate making connections with the lamp cocks. The $\frac{1}{8}$-inch pipe leading from the main pipe to the vestibule and side bracket lamps should be strapped to the roof and soldered to the tin where it passes through.

## GASKETS

**23.** The **gaskets** are really in pairs, one lead and one rubber, the two always being used together. The rubber gasket, or washer, is placed on the fitting first, the lead washer being put on next, with its collars inwards. Then, when the pressure comes on the joint in screwing up, the body of the lead washer protects the surface of the rubber one, its rib protecting the outer edge, and its collar the inner edge, of the rubber. The rubber is thus entirely enclosed within metal, and so protected from the action of the gas, which would injuriously affect it. The faces of the flanges of the various fittings are scored, the ridges thus formed making a tight joint in the lead. The Pintsch Company are now using solid lead washers of a flattened oval section.

### PUTTING ON THE GLOBES

**24.** When about to put on the upper glass, or dome, of an arm lamp, first unscrew the crown *l* from the chimney of the lamp (see Fig. 12). After the dome is in place, put this crown on again, screwing it up snugly against the dome, so as to hold the latter on tightly. Untwist a ring of asbestos wick and put it around the bottom edge of the dome at *m*, between the glass and the iron ring (see also Fig. 10); this makes the joint around the bottom of the dome air-tight. There is no occasion to solder the ventilators to the roof if the thimbles are made to fit the ventilators closely.

### BURNERS

**25.** The **burner tips** to be used on all fixtures are No. 40, shown in Fig. 26. The threads of all burners should be painted with lead paint before being screwed in. This burner consists of a small lava tip of the fish-tail variety, held in a special brass pillar. Such a burner consumes about $\frac{5}{8}$ cubic foot per hour. The No. 40 burner is recommended for all fixtures, but sometimes a No. 50 burner is used on the bracket lamps; one of these latter burners consumes about 1 cubic foot of gas per hour.


FIG. 26

## TESTING AND CHARGING

### TESTING THE EQUIPMENT

**26.** When the car is fully equipped, shut off all the fixtures by closing their cocks; also shut off the holder valves, ready for testing. To do this, remove cap *C*, Figs. 3 and 4, by means of key *K*, and then close the valve *v* by means of key *k*; these keys are shown in Fig. 3. Be sure and replace the cap *C* tightly.

Now connect a hose to *A*, Fig. 21, and then, by means of a force pump or otherwise, put in a pressure of about 15 atmospheres (220 pounds per square inch). Then close the holder valve, and if the gauge shows that the pressure does

not fall during an hour's time, the pipes, etc. may be passed. After testing, and releasing the pressure, the valves on the gas holders must be opened again. The above pressure test may be made conveniently with an air pump operated by hand.

### FILLING THE HOLDERS FOR THE FIRST TIME

**27.** Assuming the gas to be available in the charging line, turn about 1 atmosphere of pressure into the holders and then allow it to escape; fill them again with 1 atmosphere and once

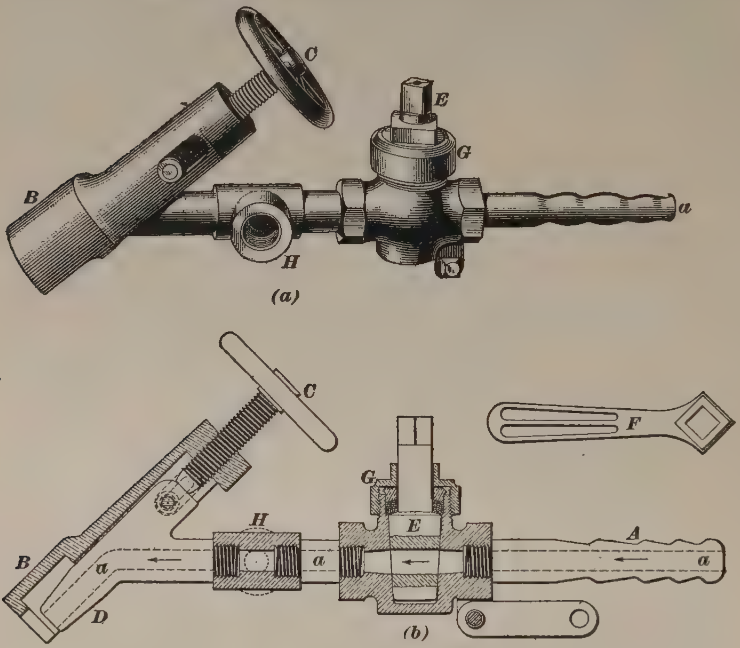



FIG. 27

more allow the gas to escape; by this means most of the air is forced from the holders. Now fill the holders to 10 atmospheres and proceed to adjust the burners.

### CHARGING THE CARS

**28.** When about to charge a car the filling valve is connected to the hose leading from the charging line by means of a special hose fitting shown in Fig. 27, in which (*a*) is an

outside view and ($b$) a sectional one. The charging hose is permanently secured to the nipple $A$ of the fitting. In making the connection, the hose fitting is brought up against the filling valve so that the clamp $B$ fits over the end of the valve and engages with the flange $n$ (see Fig. 7). The hand wheel $C$ is then screwed up, forcing the nozzle $D$ into the end $A$ of the valve, Fig. 21, making a practically tight joint, this being facilitated by the use of a small paper washer or ferrule that is slipped over the end of the nozzle before

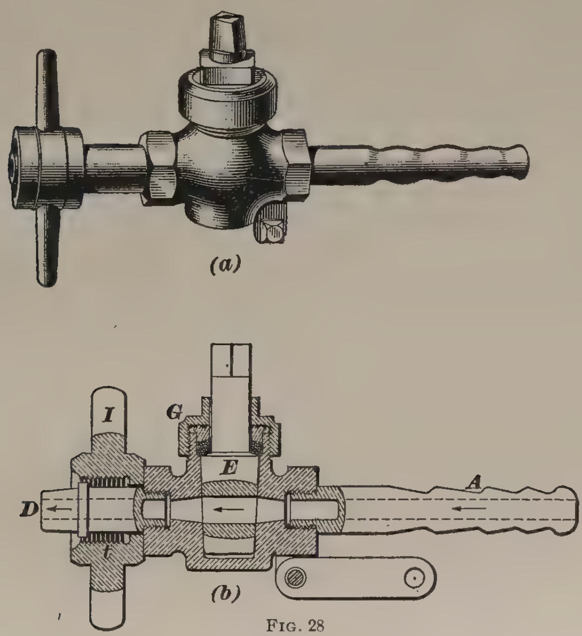



FIG. 28

inserting it in $A$. The pipe-line valve being next opened, gas flows through $a$ $a$ $a$ into the filling valve.

While passing from car to car during the operation of charging the train, the pipe-line valve need not be closed, the plug cock $E$ being operated instead, using the wrench $F$ for the purpose. This cock is kept in place by the cap $G$, a gland and packing being used, as shown. The connection for the pressure gauge is made at the **T** piece $H$.

Another hose fitting in use is shown in Fig. 28, (*a*) being an outside view and (*b*) a sectional one. The hose is attached to the nipple *A*, and the hose fitting is connected with the filling valve by entering the nozzle *D* into the valve at *A* (see Fig. 21). The joint is made tight by screwing up the sleeve nut *I*; the thread *t* engages with the screwed end **T** of the valve. (This nut is shown in its extreme positions in (*a*) and (*b*), respectively.) This fitting, as here shown, is provided with a plug cock *E*, the same as in the fitting just described, *G* being the gland cap, as before.

These hose fittings are now supplied fitted with a valve with a removable seat instead of with a plug cock. The advantages of this valve are its easy operation and the reduced liability of leakage around the stem. Also, if at any time the valve should fail to shut off properly, it can readily be put in good condition by merely changing a disk, whereas the plug cock, in such a case, would have to be ground in, and if the seat were very bad, the fitting might have to be removed from the hose in order to make use of a proper grinding machine.

## ADJUSTING THE BURNERS

**29.** Turn each burner so that its flame will stand squarely and in the right position, that is, so that the two small holes in the tip come in line with the cluster arm *l l*, Fig. 10, etc. This arm is secured in its proper position on the cluster stem by means of the locknut *w*. Adjust the screw *x* at base of burner tip until, with all the other fixtures of the car lighted and gas turned on full, the burner in question will be just on the point of "blowing"; then secure the check-screw by means of the locknut *y*.

The tops of the tips should be about $1\frac{9}{16}$ inches below the ring reflector *h* shown in Fig. 10, etc.

## CLEANING OUT THE PIPING

**30.** It is important to blow out the dirt from the inside of the pipes, jarring them at the same time to displace any loose scale. Sometimes, more especially if the above has

not been attended to thoroughly, the jarring motion of the car will dislodge dirt and scale from the inside of the pipes, and the flow of gas carries the matter along and clogs the gas ways of the lamps. When such is the case, the scale, etc. may be removed by blowing out the piping in the following manner: Disconnect the pipe *p* at the outlet of the regulator (Fig. 1) and then stop up the outlet; open the main cock and also the cocks of all fixtures and take off all the globe holders (*h*, Fig. 15) from the brackets, and also the clusters from the lamps; next, by means of a hose, connect the pipe *p* (which has just been detached from the regulator) to one of the filling valves of the car, and then, by opening this valve, allow the gas from the holder underneath the car to blow through the pipes and lamps for a few seconds. This high-pressure gas will be effectual in cleaning out the pipes, etc. After this operation is completed, check all the burners again. While blowing out the pipes in the above manner all the car windows ought to be opened.

NOTE.—No pressure should ever be allowed on the regulator outlet, whether for the testing of pipes, for blowing them out, or for any other purpose, as it will damage the regulator.

## CARE OF THE APPARATUS

**31.** The apparatus of the Pintsch system is very simple, and, with ordinary care, will yield good results continuously. At the same time, however, it is an easy matter to bring about poor results through careless handling.

### LIGHTING UP

**32. General Directions.**—First of all, see if the main cock *C*, Fig. 1, is turned on full; if it is not, turn it on. Next open the globe of the lamp. Hold the light to the burner tips and turn on the gas so as to give a small flame, not so full as to reach the reflectors and smoke them. Then shut the globe and turn up the gas so as to give a flame of the size shown in Fig. 29.

A careful and skilled attendant will, of course, look after each lamp individually; that is, he will drop the globe, turn on the gas, and then light up and close the globe. Very often one sees the attendant walk the whole length of the car (sometimes even of the train), dropping all the globes and turning on the gas at each lamp in turn; then he comes back again and lights them. All this time the gas has been escaping and filling the body of the lamp. By the time he gets back to the first ones, not only has there been quite a waste of gas, but also there is a violent "pop" on applying the light; even if this small explosion does no harm, it cannot do any good, to say nothing of momentarily alarming some of the passengers perhaps, and proclaiming to them the presence of an unskilled operator. Each lamp should be lighted as soon as it is turned on.

FIG. 29

## EXTINGUISHING THE LIGHTS

**33.** To **extinguish the lights,** turn off the gas at each lamp; do not extinguish them by shutting off the supply at the main cock. Such a careless practice will assuredly lead to a bad waste of gas (to say nothing of its unpleasantness) owing to the main cock being subsequently turned on by some one who is unaware that (possibly) some of the lamps have been left on. After turning out all the lamps, close the main cock; then, if there are any leaks beyond that point, the waste through leakage will be inconsiderable.

### POOR CHECKING

**34.** When there are check-screws, they should be adjusted so as to give the proper size of flame, Fig. 29. Lack of skill and care in adjusting the flames by means of the check-screws $x$ (Fig. 10, etc.) leads to a loss of lighting power. It is a very easy matter to bring about a loss of 20 per cent. or more in lighting power due to unskilful checking. This item should therefore be carefully attended to by the inspectors at the yards, so that the check-screws need not be moved by the train attendants.

### UNSTEADY LIGHTS

**35.** If a flame is not turned up so high as to "blow" and yet is seen to be wavy and unsteady, it is a sign that air is getting into the lamp where it ought not to. Generally the cause is either (1) that the mica chimney is broken, or (2) the joint between bowl and ring is not air-tight.

1. Carelessness in cleaning the chimney may have resulted in fracturing it, especially if it has been previously affected by too high flames. It should be borne in mind that these chimneys are necessarily somewhat frail, and should therefore be handled with a reasonable amount of care.

2. The joint between the glass bowl $A$ and the ring $r$, Fig. 10, is made by means of an asbestos wick, the ring being held against the bowl by a number of small screws. If all these screws are in place and the wick is satisfactory, the joint will be efficient. If, however, through carelessness when assembling, only one or two of these screws are put back (and especially if they are not located evenly around the ring), the joint will not be perfect, and air will leak through. Or again, the catch $t$ may be worn and the bowl allowed to drop somewhat from the iron ring $C$, thus not making a tight joint. The bowl should make a tight joint so that all the air entering the lamp must come through the proper openings.

### CLUSTER STOPPED UP

**36.** Sometimes the arms *l*, *l* or the stem *d* of the cluster may become partially choked. When such is the case, the passage in the arm *l* may be cleared by running a wire through it, first taking out the check-screw *x*. If that does not prove sufficient, unscrew the cluster from the stem *d* and clean the passage in the stem in the same way; or it may be necessary to use the twist drills furnished for the purpose. These drills are arranged to fit in a screwdriver handle, and, by their aid, any choked passages may readily be opened out.

### DIRT IN BURNER TIPS

**37.** It sometimes happens that dust or dirt from the inside surface of the pipes is carried away by the flow of gas and lodges in the burner tips, thus causing a badly shaped and smoky flame. This may be cured—but only for the time being—by tapping the cluster. The case should be reported, so that the trouble may be permanently cured by taking off the cluster and removing the dirt; new tips may also be put in if necessary.

### DIRTY LAMPS AND LOSS OF LIGHT

**38.** Although the glass bowl *A*, Fig. 10, is generally kept clean, yet the dome *B* is often neglected, perhaps because it is not quite so readily detected as the bowl. It is important, however, that this part also of the lamp should be attended to, as otherwise quite an appreciable amount of light will be prevented from reaching the upper part of the car, thus creating a gloomy appearance, even if it does not affect the passenger much as regards ability to read, etc. The opalescent dome catches and holds the dust, and also makes it harder to dislodge when cleaning is attempted; the dust obstructs the passage of the light greatly.

**39. Smoked Mica.**—By turning on the gas too full and thus allowing the flames to "blow," the mica chimney, (*i*, Fig. 10) will become smoked, and the light that should

penetrate it and pass out through the dome ($B$) is obstructed, thus throwing the car ceiling into gloom. Great care should be taken not to damage the mica during the process of cleaning it.

**40. Smoked Reflectors.**—The ring reflector ($h$, Fig. 10) and also the cup reflector ($g$) should be **kept clean.** If they are allowed to get smoked or dirty, the lighting power of the lamp will be greatly impaired.

**41. Poor Reflectors.**—Reflectors are often **burnt** and **chipped** through the flames being turned up too high. It has been carefully determined by experimenting with such reflectors that from 8 to 10 per cent. of the light is lost. This is a serious matter, and should lead, in the first place, to careful operating of the system, and, secondly, to a prompt replacing of such damaged reflectors.

## LEAKS

**42.** It is particularly important that one should never attempt to locate **leaks** by means of a lighted match, taper, etc. Instead, soap suds should be employed. The smell of the escaping gas will locate the leak approximately; then, if soap suds are applied to the suspected pipes and fittings, the leaks will be evidenced by the formation of bubbles.

## GAS CONSUMPTION

**43. Amount Consumed per Hour.** Table II gives the consumption of gas for each kind of lamp burning full on. From it we can calculate the total amount of gas consumed by the fixtures of any car during 1 hour's full burning.

TABLE II

CONSUMPTION PER LAMP

| Description of Lamp | Gas Consumed Cubic Feet per Hour |
|---|---|
| Five-flame . . . . | $3\frac{1}{4}$ |
| Four-flame . . . . | $2\frac{1}{2}$ |
| Two-flame . . . . | $1\frac{1}{2}$ |
| Vestibule . . . . | 1 |
| One-flame bracket | $\frac{3}{4}$ |
| Argand . . . . . | $2\frac{1}{2}$ |

**44. Number of Hours of Full Burning.**—In service, few, if any, cars (except postal cars) burn at full consumption throughout the entire number of hours of darkness during which they are in use. Bearing this in mind, and having determined the maximum hours of lighting, the amount of gas to be carried by any particular car for any given service may be easily computed. The calculated amount should then be increased by 15 to 20 per cent., to allow for delays, etc.

**45. Number of Holders Required.**—The necessary number and size of holders or tanks can be determined from the above-calculated results, with the aid of Table III.

TABLE III

CAPACITY OF HOLDERS

| Size of Holder | | | Capacity in Cubic Feet at 10 Atmospheres (About 147 Pounds per Square Inch) |
|---|---|---|---|
| Length | | Diameter Inches | |
| Feet | Inches | | |
| 9 | 6 | $20\frac{1}{2}$ | $212\frac{1}{2}$ |
| 8 | 6 | $20\frac{1}{2}$ | 190 |
| 7 | 10 | $20\frac{1}{2}$ | 175 |
| 6 | 1 | $20\frac{1}{2}$ | 135 |
| 6 | 1 | $18\frac{1}{2}$ | 110 |
| 6 | 1 | $16\frac{1}{2}$ | $85\frac{1}{2}$ |

**46. Pressure Measurement by Atmospheres.**—In explanation of Table III, 10 atmospheres is the standard pressure to which holders are filled; it is therefore here taken as a basis of calculation. The term *atmosphere* is used to indicate the pressure of gas in the holders. Each atmosphere, as indicated by the Pintsch gauges, represents a pressure of 14.7 pounds per square inch above that of the outside air.

A vessel that is "empty," in the ordinary sense of the word, but is open to the atmosphere, the pressure acting on the

inside of it is, of course, that of the atmosphere, 14.7 pounds per square inch. The pressure acting on its outside is exactly the same, and, therefore, to all intents and purposes, the pressure within it may be regarded as 0. If the gauge is set to register 0 when exposed to atmospheric pressure, when fixed to such a vessel the reading is 0. Now, if the vessel is sealed and the air exhausted, it will not only be "empty" but it will also be devoid of air—will contain a vacuum, in fact. There will now be no pressure within it, as a vacuum gauge now applied to the vessel would denote, but there will still exist the outside pressure of 14.7 pounds per square inch.

If two vessels of equal capacities are connected together and then closed to the outer air and all the air forced out of one into the other, a gauge on the latter will indicate 14.7 pounds, or 1 atmosphere of pressure. If the second vessel were twice as large as the first, and all its air were forced into the first, the gauge would show 2 atmospheres; that is, its pressure is increased 2 atmospheres over what it was at the start. The gauge registered 0 then, since the pressure inside the vessel was the same as that of the outer air.

If ten times as much air as it originally contained had been forced into the first vessel, its pressure would have been 10 atmospheres; so that, if the capacity of the vessel were 15 cubic feet, we should have to put in 15 cubic feet for every atmosphere we raised the pressure on the gauge. Therefore, if the number of feet in the volume of the vessel is multiplied by the number of atmospheres on the gauge, we know how many feet of *free air** have been put into the vessel over and above what was already in; and this represents the number of feet that can be drawn out at atmospheric pressure. Now, all this is true of gas as well

*By "free air" we mean air at atmospheric pressure. Thus, if we say that there is 180 cubic feet of free air in a vessel, we mean that the air in the vessel originally occupied 180 cubic feet of space before being compressed; that is, when existing in the atmosphere. If we let the air escape into the outer air, it will expand and fill a space of 180 cubic feet.

as of air, so that if we had a holder of 15 cubic feet capacity, and its gauge showed a pressure of 9 atmospheres, we know that we have $15 \times 9 = 135$ cubic feet of gas, at atmospheric pressure, available for supplying cars. This is practically true, for the gas is supplied at but very little above atmospheric pressure, only 1 ounce per square inch, in fact.

EXAMPLE.—A car has two holders, each of 19 cubic feet capacity. The gauge shows a pressure of 9 atmospheres. What amount of gas is there available for supplying the lamps?

SOLUTION.— $19 \times 2 = 38$, and $38 \times 9 = 342$, the number of cubic feet the gas will occupy when released at atmospheric pressure. Ans.

If filled at a pressure of 10 atmospheres, there will be 380 cu. ft. of gas for the lamps. When filled to 10 atmospheres, and containing, therefore, 380 cu. ft., as just remarked, two such holders will supply five four-flame lamps, two vestibule lamps, and two bracket lamps, for about 24 hr. full burning, the consumption being 16 cu. ft. per hr.

### PRESSURE IN HOLDERS

**47.** In determining the number of holders to be put on a car, it is well to bear in mind that an extra holder enables us to carry the same total quantity of gas with a lower pressure, thus entailing less liability of leakage. With only one holder, or, on certain cars, two holders, a pressure of 14 to 15 atmospheres is necessary. This is from 205 to 220 pounds per square inch, at which high pressure there must be more leakage than at the much lower pressure made available by using two and three holders, respectively.

## PROCESS OF MANUFACTURE OF THE GAS

### GENERATING THE GAS

**48.** The gas used in this system is made from distilled petroleum, and is a "fixed gas," that is, a permanent gas—one that remains in a gaseous state even when highly compressed. When compressed for use in cars, it has an illuminating power six times as great as that of ordinary coal gas. This latter—city gas—loses nearly all its illuminating power

by compression; whereas, Pintsch gas loses only about one-tenth of its power. Its illuminating power, when compressed to 14 atmospheres, is about 10 candles per cubic foot of gas consumed; that is, a lamp burning at the rate of 3 cubic feet per hour would give an illumination equal to that given out by 30 (Sugg) candles of standard specification.

The oil is contained in an underground supply tank located outside the gasworks proper. It is pumped up, as required, to a smaller supply tank, whence it flows by gravity to the retorts in which it is treated. These retorts are of fireclay (which stands the heat better and is cheaper than iron); they are heated by coke fires in a regenerative furnace. The gas liberated from the oil leaves the retorts through pipes leading into a hydraulic main located above the furnace. From there it goes to the condenser in the purifying room, at which stage a test is made of the quality of the gas. The gas passes through tubes inside the condenser, cold water circulating around these tubes; all moisture and tar are thus removed from the gas, passing off to the tar well.

The pressure inside retorts made of clay must not exceed a certain amount; therefore, when such are used, an exhauster has to be employed for the purpose of maintaining a constant pressure of 1 inch of water inside the retorts. From the condenser, the exhauster passes the gas to the washer, or scrubber, where all products requiring mechanical removal are extracted. From the purifier, the gas passes through a meter and thence to a gas holder outside the building. It is then ready for compression, and, at this stage, further tests are made of its quality.

## COMPRESSING THE GAS

**49.** Economy is secured by compressing in two stages. The theoretical limit of the pressure at the first stage is the square root* of the total pressure. In actual practice, when

*The square root of a number is that number which, multiplied by itself, produces the given number. Thus, 3 multiplied by 3 equals 9; therefore, 3 is called the square root of 9. Likewise, $3\frac{3}{4}$ multiplied by $3\frac{3}{4}$ equals 14, very approximately; $3\frac{3}{4}$, therefore, is the square root of 14.

the pressure attained in the second stage is to be 14 atmospheres, the first stage of compression is from $3\frac{1}{2}$ to $3\frac{3}{4}$ atmospheres. The compression and cooling from the second stage causes the deposit of hydrocarbons, which are collected in pots outside the building. After being compressed, the gas is stored in welded steel holders. When two-stage compression is adopted, one of these holders acts as a reservoir or receiver between the first and second compressors.

The gas is led to the charging stations through extra strong 2-inch pipe, under a pressure of about 14 atmospheres. Where the length of the mains warrants it, expansion bends are provided. In the plant of the Manhattan Railroad, New York, there are 11 miles of this piping, the expansion bends being $\frac{1}{2}$ mile apart. Notwithstanding the length of this piping, the loss in pressure is less than 10 per cent.

# CAR HEATING
(PART 1)

## EARLY METHODS

### INTRODUCTION

**1.** The early method of heating railroad coaches, which was by stoves, was not satisfactory, because the heat was not disseminated throughout the car, being limited to the immediate neighborhood of the stove. Besides this, when wrecks occurred, the stoves generally set fire to the cars and greatly aggravated the catastrophe, so that in many states the use of stoves for heating passenger cars is prohibited by law.

At the present time, on all progressive roads, more efficient methods have been adopted—the most important one being that of heating by steam from the locomotive, using either live or exhaust steam. Naturally, the severe climatic conditions in some parts of the United States led to considerable thought on the subject of car heating, with the result that now there are several very safe and efficient methods in general use, the most important ones of which are described in detail.

### THE BAKER SYSTEM

**2. General Remarks.**—The first scientific and successful attempt to grapple with the important question of car heating was undertaken by William C. Baker. While the Baker heater is a stove containing fire, the common objection to the fire-stove—that it is liable to set the car on fire in case

of a wreck—has been gradually minimized, the heater being now built so substantially and carefully as to practically insure safety from fire in the event of a wreck. Besides, steam from the engine is generally used to heat the water, fire being used in the heater only when the car is detached from the source of steam supply. Steam from the engine for heating cars was introduced in 1878.

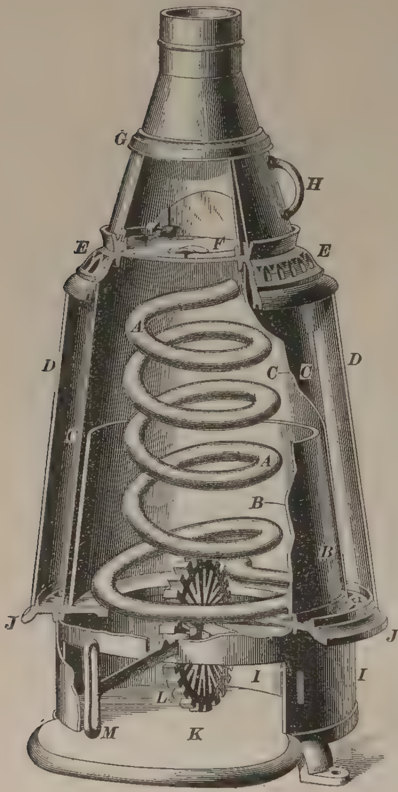


FIG. 1

**3.** In Fig. 1 is shown the ordinary Baker heater, in which *A* is the generator coil, sometimes spoken of as the water coil; *B*, the fire-pot; *C*, the inside casing; *D*, the outside casing; *E*, the top casting; *F*, the safety plate; *G*, the base of the smoke flue; *H*, the feed-door; *I*, the ash-pit; *J*, the ash-pit casting; *K*, the base of stove and bottom of ash-pit; *L*, the grate shown in position for dumping; and *M*, the rocking bar and shaker for the grate. The castings *E* and *J* are perforated, as shown, so as to permit an upward circulation of air through the space between the casings *C* and *D*. The air between the casings is heated, and so expands and rises, while cool air is forced in through the holes in the casting *J* to take its place, thus maintaining an upward circulation of the air. The generator coil *A* is connected to the heating system and is always filled with the liquid used in the system; the heat from the fire heats

the liquid in the coil *A*. The liquid expands, rises, and passes out of the coil at the top, while cooler liquid enters the coil at its lower end to take the place of the water heated; thus, an upward circulation is maintained through the coil *A*.

The water coil is shown in Fig. 1 with the coils apart so as to give a better idea of its form. In service, the coils are close together so no coal can work between the coils to the outside. Fig. 4 shows the coil as it really is.

**4. Expansion Drum.**—In addition to the fire enclosure and water coil, which make up the heater proper, the Baker comprises a **circulating, or expansion, drum,** and the necessary radiating pipes, through which the hot water is carried to all parts of the car, together with the cocks for filling or draining the system.

This expansion drum, Fig. 2, is always attached to the highest point of the heater—on the roof of the car for choice. Its purpose is to hold the water required for the circulation, after the pipes are all filled, and also stores a sufficient quantity as a reserve. As water expands when

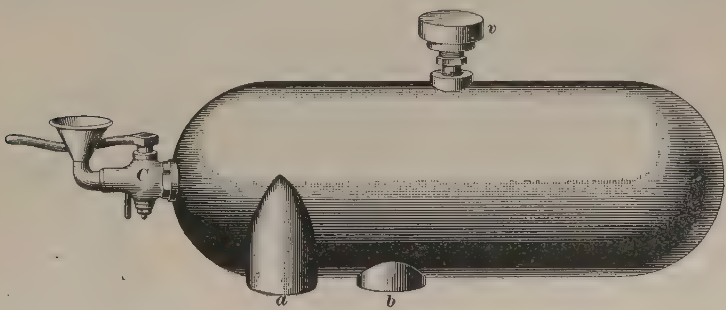



FIG. 2

heated, there must be a chamber for it to expand into; when it cools off and contracts, the water in the expansion drum keeps the pipes full. The drum is placed horizontally, as in Fig. 3. The cock *C* is located so as to utilize the lower half of the drum for water storage. The upper half serves as an air chamber, which acts as an expansion chamber, and is

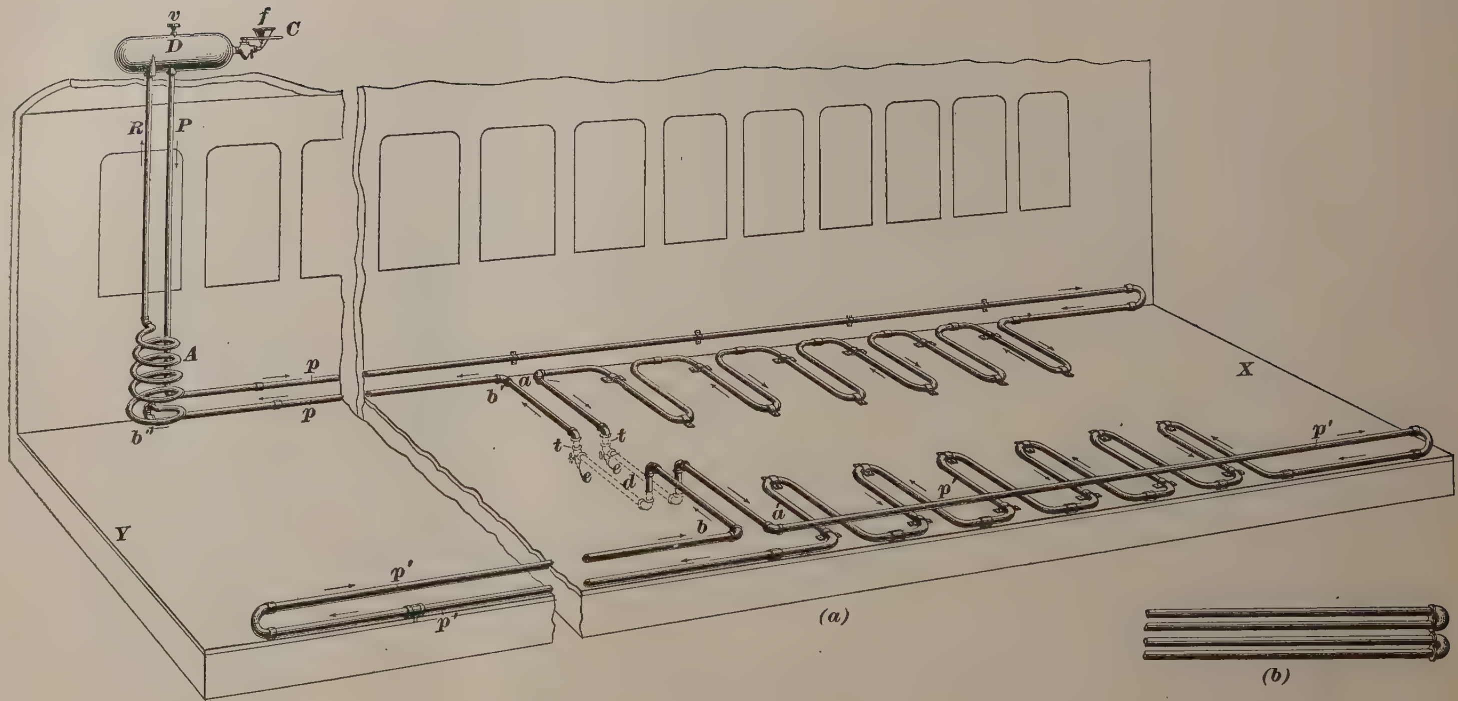



FIG. 3

indispensable in securing free circulation. The air that is freed from the pipes when the water is first heated rises and gathers in this drum. The bottom of the drum has two tapped holes *a*, *b* into one of which enters the upflow pipe from the heater, while from the other runs the circulating, or downflow, pipe that carries the hot water through the car.

If the fire were allowed, through inattention, to run on unchecked, or the water circulation were impeded, the pressure in the heater might mount dangerously high. It is therefore essential that a pressure-relief or safety valve be provided to release the pressure before it reaches the danger point; this appliance is a cast-iron safety vent *v*, Fig. 2, screwed into the top of the circulating drum. This vent is a single casting without any joints; its top is thinned down to a certain specified thickness, thus providing a weak place that yields when the pressure attains a certain degree, about 125 pounds, and allows the top to be blown off.

When the top is thus blown out, a new safety vent is required, but the bushing may be used again. More or less water will be lost when the top blows off, which must be renewed. The fire must be put out as soon as the safety vent gives away, in order to protect the heater coil.

**5. The Car Piping.**—Fig. 3 shows a method of piping a car for the Baker system of heating. The expansion drum *D* is placed horizontally on the roof, while the heater, represented here by the heater coil *A*, is placed as low down as practicable; namely, on the floor of the car. *R* is the hot-water riser, or upflow pipe, through which the heated water ascends into the drum *D*; *P* is the pipe through which it descends into the car again on its circuit through the latter. Near the floor of the car, pipe *P* joins with the line of piping *p*, which runs to the far end *X* of the car, then turns, and in a series of loops, under the seats, comes back to point *a*, where it crosses over to the other side, makes a turn at *a′* and runs through the pipe *p′* to the same end *X* as before; thence it returns in a series of loops, makes the return bend at end *Y*, recrosses the car at *b*, and

at $b'$ starts to return to the heater, entering the bottom of the coil at $b''$. The arrows serve to make clear the course of the circulation.

The pipe, in crossing the car, dips below the floor at $d$, as shown, a **T** fitting being placed at $t$. At $e, e$ are drain cocks to drain off the water when required. The pipes crossing from one side of the car to the other under the car are called *cross-over pipes*. The car is represented as being broken in two, and the two parts brought close together.

The later method of arranging the piping is to put it in four lines next to the truss plank along each side of the car with the same arrangement of cross-over pipes, shown in Fig. 3 ($b$).

**6. Circulating Action.**—As the water in pipe $R$ becomes heated, it expands and rises into the expansion drum, starting a current out of the top of $R$. Cooler water flows in it at the bottom to take its place; this, in turn, is heated, and rises, so that a continuous flow is maintained. Also, the water in the pipe $P$ is cooler than that in $R$; consequently, it weighs more, and thus exerts a pressure on the water in pipe $p$, causing it to circulate in the piping, part with its heat, and reenter the coil $A$ at its lower end. Encountering the heated pipes in the fire, the cool water is again heated, rises through the coil and into the drum, and is again discharged through the pipe, leading from the drum to the radiating piping, to impart its heat to the car and cool off again. In this way a constant upflow of hot water is maintained through the coils into the drum, and a downflow from the drum into the pipes in the car. This continuous circulation of the body of water evenly distributes the heat throughout the car as the hot water from the heater goes directly to the other end of the car. On its way back to the heater, it circulates through the pipes that are on the other side of the car opposite the heater so that the coolest water is in the piping nearest the heater.

The drum is filled through the funnel $f$ and cock $C$. The funnel, after being filled, should be turned downwards so as

not to collect dirt or cinders. The cock is also provided with a drip pipe. In order to secure a more rapid and certain circulation in the system, it is of importance to have the upflow pipe $R$ as long as possible; therefore, the heater should be placed as low, and the drum as high, as practicable.

In large coaches, it is usual to put two coils in each heater, one for each side of the car. This gives more heating surface in proportion to the radiating surface with better results in cold weather. Two expansion drums are used, so that the two sides are separate in every way.

---

## BAKER FIREPROOF HEATERS

**7. General Description.**—In Art. **3**, Fig. 1 was alluded to as the ordinary Baker heater; this term is used to distinguish that heater from the one now about to be described, and known as the *fireproof heater*. One of the main objections to heating cars by fire is the danger of hot coals being scattered in the event of a wreck, thus setting the cars on fire; this danger is reduced to a great extent by the use of the **fireproof car heater** shown in Fig. 4.

In Fig. 4, $D$ is the fire-safe, which is constructed as follows: The outside shell, or casing, is made of a flexible grade of steel, and is without seam or joint; its depth is from $a$ to $a$, as shown. Next to this shell on the inside are placed sheets of asbestos. Inside of this asbestos is a sheet-iron casing $C$, enclosing the generator coil $A$; between this casing and the coil is an air space that accommodates the hot gases of combustion. The space enclosed by the coil serves as the fire-chamber. Thus, the fire in the heater lies within four casings: ($a$) a water casing, so to speak, formed by the close-wound pipe coils filled with water; ($b$) a sheet-iron casing; ($c$) an asbestos sheeting; and ($d$) an outer casing of steel plate.

The only open communication between the fire and the outer air is through the small holes in the draft, or ash-pit, door $K$; if the heater should, in a wreck, have the smoke-flue

base $G$ unshipped, the fire could only escape through the small holes in the top $E$, and these holes are smaller than the smallest size of coal that it is intended should be used.

In Fig. 4, a part of the smoke screen $N$ is seen; this is a cone-shaped casting, open at the front where the coal is fed in, this opening being just behind the feed-door, of course; the coal passes through the bottom of the casting, and through the coal feed-chute $o$ into the fire. This hole in the bottom of the screen is closed by the safety plate $F$, which is controlled by the hand lever $h$, the latter being held in place by the spring $i$. The top of the screen contains small holes, as shown, for the smoke to pass through.

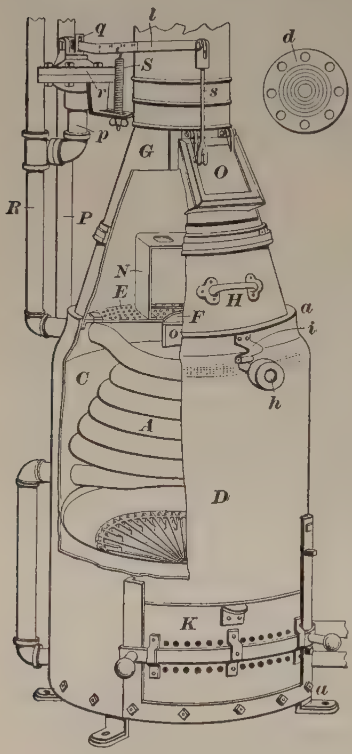


Fig. 4

**8.** In this heater, the fire is surrounded by asbestos sheets on the sides, while the feed-chute is covered by the safety plate and the ash-pit is closed by a cinder-proof door. In addition, there is asbestos sheeting between the ash-pit bottom and the sheet-iron bottom of the heater. Thus, the smoke pipe and smoke-flue base might be broken off in a wreck, and yet leave the fire-chamber intact and practically fireproof.

**9. Regulating the Heaters.**—The fireproof heaters just described are fitted with an arrangement for automatically regulating the fire according to the pressure in the heater and, therefore, the temperature in the radiating pipes; this draft regulator is marked $r$ in Fig. 4. A pipe $p$ leaves

the riser $R$ at the point shown and runs into the regulator bowl, which is made up of two concave pieces bolted together. Between these pieces is a corrugated steel diaphragm $d$, which is shown separately at the right of the figure; this diaphragm is of tempered steel and has a thin copper sheet on both sides of it—of exactly the same shape, of course. The underside of the diaphragm is exposed to the pressure that is in the pipe $R$. The rod $q$ passes through the top of the bowl and rests on top of the diaphragm $d$.

As the pressure in $R$, and therefore in the bowl, increases, the flexible middle portion of the diaphragm is forced up, lifting the rod $q$ against the action of the spring $S$ and the lever $l$, thus raising rod $s$ and lifting the counterdraft door $O$, which thereupon checks the draft through the fire. As the pressure in $R$ falls, the diaphragm moves downwards, and the spring $S$ pulls the lever $l$ downwards and closes the door $O$. The effect is then to cause more draft through the fire, and thus make it burn more briskly. This spring has a loop in its upper end, which may be placed in any of the holes shown in lever $l$. The nearer it is placed to $q$, the less will be the force on the diaphragm necessary to raise $l$. Each hole is marked with the corresponding pressure in the heater, that is, the pressure at which the door will be open to check the fire when the spring is in that hole. As the temperature varies with the pressure, it is seen that $r$ is therefore really a temperature regulator, which is the feature required.

## MANAGING THE APPARATUS

**10. Filling the Pipes.**—The water used in this heating system, which is called a *closed circulation*, is salted water, or brine, the purpose of this being to prevent the pipes freezing in cold weather when not in use. If fresh water were used it would freeze at a temperature of 32° F.,* and constant danger and annoyance would ensue when starting

* The sign ° stands for degrees and F. for Fahrenheit. Thus, 32° F. means 32 degrees above zero on the Fahrenheit scale.

up the fires again. Salt water has a much lower freezing point than fresh water, and the more salty it is the lower is the temperature at which it freezes. Care must be taken, of course, to see that the right degree of saturation is attained; in other words, that the water is salty enough. With the brine properly prepared, the pipes and fittings will not freeze even if standing for days together with the fire out, until the temperature drops to 1° above zero. That salt water will not injure the heater pipes has been proved by the examination of car systems that have been taken apart after many years' service, and found to be quite free from rust or salt deposits. When about to fill a car, have a barrel or other vessel of brine prepared beforehand. In it put an extra amount of salt over and above what immediately dissolves, and then keep stirring it up from the bottom occasionally; after standing 12 hours the excess of salt will be at the bottom and clear water above. If only this clear salt water is used, there will be no deposit formed in the pipes, and at the same time the water will be salty enough to stand a very low temperature without freezing. Water will take up 25 per cent. of its weight of salt, up to the point of saturation, at ordinary temperatures.

There has been much discussion as to the proper methods of charging empty Baker heater pipes with salt water, and many different plans have been adopted, some of which do not produce the absolutely solid body of water in the pipes that is essential to proper circulation. In order to secure this solidity of water, all air, dirt, and scale must be expelled from the pipes, which must be filled with water that is free from air bubbles. The plan here given has proved a good and sure method.

1. *Filling by Condensation.*—Open all draw-off or drain cocks in the circulation piping, remove the safety valve, but keep the combination cock closed, and run from the topmost tapping in the expansion drum a $\frac{1}{2}$-inch pipe, as shown at *A A*, Fig. 5. This piping must be made up so as to be absolutely tight. Extend the $\frac{1}{2}$-inch pipe downwards toward the ground outside the car, and connect it to the upper end

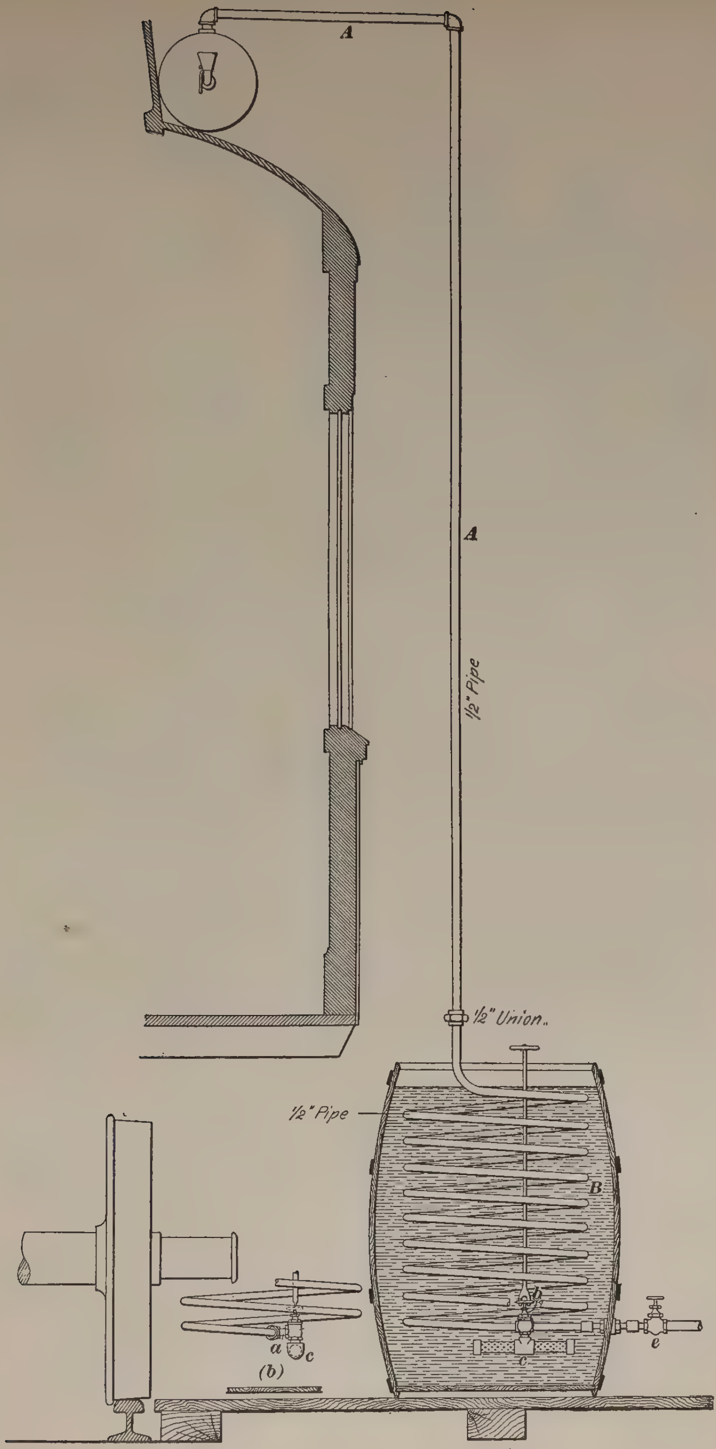



FIG. 5

of a coil of pipe in a barrel or tank, placed as close to the car as convenient.

This coil *B* is made of $\frac{1}{2}$-inch pipe, and should be made up about 2 inches smaller in diameter than the inside of the barrel, and coiled as closely as possible, so as to get in a large amount of heating surface. Near the lower end is placed a **T** fitting *a*, view (*b*), to which is connected an angle valve *b*, view (*a*); this valve has an extension handle that reaches above the top of the barrel. In order to prevent the salt or other solid matter getting into the pipes, a metal strainer *c* is attached to the angle valve. A convenient form of strainer is illustrated herewith, but any form will do, provided that it has at least twenty-five $\frac{1}{8}$-inch holes in it. The lower end of the coil is connected with the globe valve *e*. View (*b*) shows the lower portion of the coil, with the angle valve and strainer in position, as seen if viewed from a position opposite the valve *e*.

Fill the tank with the brine or fresh water (brine preferred) with which it is desired to fill the pipes. The brine should contain a considerable amount of undissolved salt over and above that which the water will take in solution. The water in the barrel must, of course, be sufficient to fill the pipes without drawing the level in the barrel too near the strainer; at no time should the water level be less than 4 inches above the strainer. One hundred feet of $1\frac{1}{4}$-inch pipe contains about $7\frac{1}{2}$ gallons of water; so, if the number of feet of circulation piping is known, the water necessary is easily calculated. An excess of at least one-third should then be allowed for as a measure of safety. An ordinary barrelful of water will suffice for all ordinary cars, or for each half of a double-circulation car, but it is well to have an extra amount on hand to use in case the water level in the barrel should be lowered too near the strainer, otherwise air might be taken into the system.

Close the angle valve *b* and open the globe valve *e*. Connect a steam hose to the draw-off cock farthest from the expansion drum, and blow about 25 or 30 pounds of steam into the pipes. As fast as it issues freely and in full volume

from each open draw-off cock, close that cock. In a very few minutes every foot of the heater pipes will be full of live steam, as will be indicated by the temperature of the pipes, and the steam will force its way into the expansion drum and through the coil *B* and the globe valve *e*. It carries with it the air that has collected in the pipes, and this, together with the water of condensation, will be discharged from the globe valve *e*. If live steam escapes with the water, close the valve a little, or until only water and air escape.

After the air is expelled, the steam heats the water in the barrel to the boiling point. This act of boiling expels the air that is always in suspension in any body of water not boiled; when the water in the barrel is salty enough to float a potato while boiling, it is suitable for use in the circulation pipes.

Close the globe valve outside the barrel and the draw-off cock through which steam enters the pipes; also, disconnect the steam hose. Then open the angle valve inside the barrel. The steam issuing from the pipes now escapes into the brine in the barrel, and continues to escape into it until the pressure reduces. The steam remaining in the pipes condenses and forms a vacuum, into which the boiling-hot brine from the barrel is forced by atmospheric pressure, and, if the work has been carefully done, in a very few minutes the pipes will be completely filled. This will be indicated by the level of the water in the barrel becoming stationary.

The ½-inch piping can now be disconnected, and the drum will be found full to the top. Draw it off, through the combination cock, to the level of this cock, and replace the safety valve. After standing for some hours, the water, having cooled, will contract to some extent, and a small amount of water may then be added by hand through the combination cock. The heating system is then ready for service.

Double-coil circulations require separate treatments, just as if they were separate cars.

2. *Filling With a Force Pump.*—To fill the piping with a force pump or from a hydrant, open all the draw-off or drain cocks and the filler cock in the expansion drum.

Some coaches have more than two drain cocks under them; with a double circulation there may be four. Connect the water hose to the drain cock that has the longest section of pipe between it and the expansion drum and allow water to flow in; it will almost immediately begin to flow out of the next drain cock in the same line of piping or cross over, in a solid stream, when this cock should be closed. The water will then pass into the pipes, filling them up from the bottom and forcing the air out ahead of it. When a solid stream comes out at the filler and drain cocks still open, they can be closed and the system is filled. If salt water is used, the water passing out at the drain cocks is allowed to flow back into the supply tank or barrel from which the pump draws its supply, so that none will be wasted.

The water thus put in the system will have considerable air with it. After it has been circulated by heat for a few hours, this air will separate; the filler cock should be opened to allow the air to escape from the expansion drum and more water added.

At points where the proper filling devices are not at hand to fill the pipes, a connection can be made to the delivery pipe of an injector; steam should first be blown through the pipes as has been explained, and then hot water until the pipes are filled.

When filling with a pump, it is usual to test the pipes with a high pressure to locate any leaks or weak places. After the drain cocks and all openings from the pipes are closed and while the water is still under pressure, if there is any air trapped in the pipes, when the filler cock is opened, this air being compressed will force water out at the filler cock in proportion to the amount of air entrapped. If only a quart or so of water comes out, the system may be considered full for service. With two expansion drums, double-coil circulations require filling separately.

**11. First Firing Up.**—Build a light wood fire, and fire up slowly until the circulation of hot water is complete, which may be known by the piping being hot all the way around

the car and back to the bottom of the coil. If the water does not circulate properly it is likely that air is trapped in the piping, in which case it may be necessary to refill the piping to force the air out. Then allow the fire to go down and the pipes to cool off. It may probably require two or three firings and subsequent coolings before the air is all exhausted from the pipes and the water "solid." After the first firing, it will, as a rule, be found that the heater will take in considerably more water. This matter of renewing the water should be carefully looked to for the first few days; a slight deficit may have to be made good each day for the first week or so. When once the water has become solid throughout the heater and pipes, any further renewal of it will be seldom found necessary; still this point should be tested from time to time to make sure that everything is right.

**12. Testing, Renewing, and Drawing Off the Water.** When testing the water, that is, ascertaining the amount in the heater and piping, the fire must be low and no pressure in the heater. The test is made by noting the height of water in the drum, which is done by means of the combination cock *C*, Fig. 2. If the water is at the right height, it will run out of the drip pipe when the cock *C* is opened. If found necessary to renew the supply of water in the system, it may be done by putting water in through the filling funnel *f* that is attached to the cock *C*. After renewing the supply of water, close the cock *C* and turn down the funnel. Occasions sometimes arise when it is necessary to empty the water from the heating system. To do this, draw off the water through the cock *e* in the cross-over pipe, Fig. 3, observing at the same time to open the cock *C* in the drum to act as an air vent; that is, to let in atmospheric pressure for the purpose of assisting the water to flow out more readily. If there is an extra drain cock in any location where water can be pocketed in the piping, open such cock and drain off the water. The system should not be emptied unless it is absolutely necessary, as, for instance, in the case of repairs, or in very cold weather when from any reason the circulation has

stopped and cannot be started. In such a case the fire should be drawn and all water let out of the drain cocks to prevent damage to the pipes from freezing.

**13. Low Water.**—As long as the water is kept solid in the pipes and is maintained at its proper height in the drum, the circulation will be satisfactory throughout the whole system without having any pressure in the heater. If, however, the water is allowed to get low enough to leave the drum empty, or the temperature of any of the pipes gets so low that the water freezes in them, circulation will stop, the pressure will mount up, and the safety vent probably blow out. If the water is allowed to get so low as to leave the coil, the latter will burn out.

In case of a safety vent blowing out, the fire must be drawn at once; the water should then be renewed, so as to come up to the level of the combination cock *C*, another vent *v* screwed into the drum, and the fire relighted.

**14. Conditions Affecting Circulation.**—When the heating system is working properly, the water in the heater coils, risers, and radiating pipes forms one continuous body that keeps circulating around the car, the motive power being the heat in the fire around the coils *A*, Fig. 3. This heat, in passing through to the water in *A*, heats the water and causes it to rise, and the cool water below, which has given off its heat to the atmosphere of the car, flows through the return length of pipe and takes its place. At the same time this cool water in the pipes is replaced by hot water from the expansion drum. The cool water that has just come into the coils is, in turn, heated by the fire, and then rises and passes up *R* into the drum; it then goes down *P* and around the system once more, again giving off its heat to the car.

When the system is cold, the space in the pipes is fully occupied by water, and the upper part of the drum by air. We assume the system to be in good working order, and the pipes therefore to contain no air. When the fire is lighted and the water in the coils heated, this water expands and

occupies a larger volume. Water itself is practically incompressible, while air is compressible to any extent; therefore, the only way in which accommodation can be provided for the heated water is by the air being compressed in the drum. The principal impediments to an easy flow that are likely to arise in a heating system are: (*a*) neglect to maintain the water at its right height; (*b*) pressure of air trapped in the piping; (*c*) obstruction in the piping; (*d*) too great a length of piping; (*e*) too many turns—elbows, bends, etc.—in the piping.

**15. Safety Vent.**—On the old-style Baker heater, the safety appliance consisted of a rubber ball held between two brass plates. The screws holding these plates must be left as they were originally; that is, the plates must not be screwed any closer together than intended. Every time this valve blows off it spoils the ball; therefore, a new one should be put in. Very few of these ball safety valves are now in service; the cast-iron safety vent is more reliable.

**16. Testing the Circulation.**—It can be ascertained whether the circulation is going on properly or not by feeling the pipes near the heater. If the riser *R* and downflow *P* are hot, while the pipe *p*, where it enters the stove after making the circuit of the car, is cool, the system is working properly. If, however, the circulation is stopped, the pipe *p* near the heater will get hot and the pipe *P* will get cool. If a car is found to be cold, first examine the fire, and if that is going all right, test the circulation. To do this, feel of pipes *p*, *R*, and *P*. If pipe *p* is cool and pipes *R* and *P* are hot, there is circulation, and it will not be necessary to dump the fire. If this has stopped, put out the fire for fear the system should be short of water, and the heater coil therefore be in danger of burning. Then, if the weather is severe, rendering the prompt renewal of heat imperative, renew the water in the drum at the next station stop, first allowing the steam to escape out of the filling cock *C*. If the drum is found to be very hot, take out the safety vent and pour in cold water until the drum is half full. Then replace vent,

turn down the filler, and restart the fire. If the circulation does not now commence, there may be an obstruction in the cross-over pipes. Try the effect of a sharp, sudden blow-out, opening the cocks fully, but losing not more than a quart at each cock, or else the water in the drum will be lowered too much. If the circulation still fails to start, draw the fire and empty all water out of the car, letting it drain out while running, opening the funnel on the drum to let air in to assist the emptying process.

**17. Managing the Heater.**—In starting the fire, use sufficient wood, not over 2 inches thick, to start the fire quickly. Light the kindlings first, and check the draft so as not to get too sudden and sharp a fire. When the fire has a good start, add the coal gradually, and afterwards keep the fire-pot full.

In starting a fire, one may feel assured that the heater is working well if the lower pipe is cool close to the place where it enters the fire. This should always be the coolest part of the piping and the top pipe, where it leaves the fire, should always be the hottest part. When the heating system is at its best, the piping will be hot all around the car without there being any pressure in the system.

Hard coal, clean and free of slate, and of the proper size, should be used. If the coal is too large, pieces will lodge against the coils instead of settling down on the fire-grate. If the coal is too fine some of it will work between the coils and overheat the sheet-iron jacket. Keep both the feed-door and the ash-pit door closed, except while starting the fire. Cool or check the fire by opening the feed-door; that is, the upper door. Never have both doors open at the same time, as the one counteracts the effect of the other. Never go away and leave the draft full on, and never let the fire go out in cold weather. When the automatic regulator is in use, it should be properly adjusted to suit the weather, and then the fire itself can be left to control the draft. During such times, as when little or no heat is wanted, unhook the spring *S* from the lever *l* and thus let the door *O* remain open; this checks

the draft through the fire. Never let the fire get so low as to require rekindling, but keep a good clean fire night and day as long as the car is in service.

The feed-door must be kept closed at all times except when putting on fuel, the ash-pit should always be kept clear, and the ash-pit door should only be opened when removing ashes and cinders.

The feed-chute should be kept well filled with fuel, the fire burning well and kept clean below. Shake the grate only when the fire shows dark underneath.

The safety plate and gas preventer is located over the fire-chamber; it must be kept fastened down at all times except when putting on coal. Its duty is to prevent any fire from spilling out in case of a collision or wreck. It is also intended to prevent coal gas from escaping into the car. In the fire-proof heater, Fig. 4, this safety plate *F* is placed under the top head of the heater, over the fire. It must always be closed after firing, etc.

**18. Pressure Gauge.**—The function of the **pressure gauge** is to indicate the pressure within the heater. Thus, the figures 10, 20, etc., on the dial refer to pounds of pressure. If the heater is in good order, and the instructions herein given for its management are faithfully followed, no excessive pressure can result. Attention is directed to the fact that the less pressure at which the heater can be operated, the better.

## SUMMARY OF INSTRUCTIONS

**19.** The whole of the foregoing instructions as to the fire and water in this system may be condensed into two rules, the strict observance of which will, in any of the heaters here dealt with, result in perfectly satisfactory working: (*a*) maintain the water at the right height, and see that it is kept solid throughout the pipes; (*b*) keep up a slow, steady, constant fire.

## HEATING BY STEAM

### GENERAL CONSIDERATIONS

**20. General Instructions.**—In using direct steam, or steam from the locomotive, to heat railway cars, it is impossible for any pipes, valves, or traps to freeze up while dry steam, steam and water mixed, or hot condensed water is flowing through them. If the system—whatever one it may be—is operated according to instructions, there is no danger of this trouble. But if the steam pressure furnished from the engine is too low, there is danger of the rear cars in the train having so small a supply that the temperature of the pipes, valves, and traps may get so low that the condensed water will give trouble in very cold weather. This applies especially to traps or valves located outside the car body, unless they are connected by a special fitting to the train pipe.

A steam valve, either inside the car or in the train pipe, may be so nearly closed that the proper amount of steam will not pass it to keep the pipes in the car warm. If the condensed water in these pipes becomes cold before it reaches the trap, and the trap is also cold, it will surely give trouble. This is something for the trainmen in charge of the heating apparatus to look out for; they must either keep the pipes warm or open all valves so any condensed water will pass out in the proper manner.

Some makes of hose couplings have a trap that will relieve the couplings of any condensed water when the steam pressure drops below a safe amount; other makes of couplings do not and they should be uncoupled and allowed to drain when steam is shut off. Always hook up the steam hose with its chain so that it will not drag and get torn off.

With any system using steam from the engine, the train pipes should be blown out with dry steam when steam is

first turned on, and also just before the steam is shut off at the engine when nearing a terminal. If at the same time that the steam is shut off at the engine, all the steam valves, whether in the train pipe or inside the cars, or in case there are any connected with traps, are opened, the pipes will be free and ready for steam to pass through them when it is next turned on. Most traps for discharging condensed water are automatic and do not need any adjusting while on the trip.

**21. Regulation of Temperature.**—The regulation of the temperature of the cars is usually in charge of the trainmen; if this work is intelligently performed, the cars will be comfortable. The Air Brake Association, which has as its members a large number of men acquainted with the practical operation of steam heating, decided that where a hot-water circulation heated with steam was used, a train-pipe pressure of about 5 pounds per car in the train was necessary. For a four-car train or less this means 20 pounds, while for a train of twelve cars, 60 pounds at the engine would be proper. It takes much less for direct steam; just how much, depends on the weather and the condition of the piping and connections.

Direct steam is 212° in temperature in the heating pipes or else is condensed water, while hot-water pipes may not have as high a temperature. This is one reason why direct-steam heated cars get too hot at times and when the supply of steam is shut off at the valve inside the car they soon become cold. With hot water, the temperature rises more slowly and of course falls more slowly; trainmen should remember these facts when regulating the temperature.

**22. Heating a Cold Train.**—Instructions for heating a cold train require that when attaching the engine to the train, all hose shall be coupled, all train-pipe cocks wide open, a good stiff pressure of steam be turned on, and the train pipe blown out until dry steam comes out at the rear end of the train. This is to clear the pipes of all condensed water and also to prove that the pipe is open to the last car.

When the steam is turned into a cold train pipe, it begins to condense at once; this condensed water is driven along the pipe ahead of the steam and out the rear end until the whole pipe is warm. It is much better that this water be blown out at the rear hose than wait for it to be forced into the cars and then slowly pass out through the hand-operated drips, blow-out valves, or automatic traps.

When the train pipe is filled with live steam throughout its entire length and the rear train-pipe valve closed, begin to admit steam to the car heaters at the last car. As soon as it is passing freely into this car and coming out at the trap, go to the next car ahead and do the same for each one until the car next the engine is being heated. The reason for this is, that if you begin at the head end of a long train to open the valves that admit steam to the car heaters, it will take some of the supply of steam and reduce the pressure so much that by the time the last car is reached, there will not be steam of sufficient pressure to promptly blow through the heaters and warm the car. Also, steam will flow into a hot car with no condensed water in the pipes and the trap or drip working correctly, more readily than into one with the pipes full of condensed water; in this way the head cars usually get more than their fair allowance of steam.

Some railroads place reducing valves in the steam supply pipes inside the cars next the engine, such as baggage, mail, and express cars; these reducing valves are set at as low a pressure as will heat the cars properly and thus the steam pressure in that car is automatically regulated.

It is a well-known fact that the cars in which the heaters are working properly "steal the steam" from the cold ones, so that when some of the cars in a train, usually the rear ones, begin to get cold and do not get their proper supply of steam, if the other cars ahead of it are shut off for 5 minutes, and in extreme cases the train pipe blown out at the rear, the defective car will begin heating up. The hand-operated drips or blow-off valves should be opened wide in a cold car and left open until the steam begins to pass through these valves. This will show that

there is no condensed water left in the car in case it is cut off before steam gets through it.

**23. Frozen Traps and Couplings.**—When the condensed water freezes in the opening of a cold trap, or in the lower end of any pipe leading from a drip or blow-out valve, it can usually be thawed out by throwing hot water on it; or if it projects far enough below the car body immerse it in a pail of hot water until the ice is gone. When a hose coupling, hose, or train pipe shows signs of being filled with ice, couple it to a steam hose and turn on steam, taking care to have the couplings at the lower end of the frozen hose leak so that the water will flow out. This will allow the live steam to thaw out the frozen coupling and work upwards through the hose, melting the ice in it from the bottom up; the water from the melted ice will run to the leak, which should be lower than any of the frozen parts.

In adjusting traps or the opening of drip valves, remember that it is not necessary to have live steam blowing through them constantly; if the trap can be adjusted to pass hot water only and not steam, it should be done. Live steam passing out is not only a waste, but it is sure to scald the varnish on the sides of the coaches.

**24. Steam-Heat Gauge Pressure.**—Sometimes the steam-heat gauge in the cab indicates that the proper pressure of steam is in the pipes, but it is not known that the gauge is correct. In such a case, shut off the steam at the boiler, close the reducing valve, part the hose couplings at the rear of the tender and turn on the full head of steam. If the reducing valve is working properly, a very small amount of steam will come out at the hose; screw down the reducing valve to increase the train-pipe pressure and see if the supply of steam is increased proportionately. When satisfied that the reducing valve is operating properly, shut off the steam, couple up the hose, and test the gauge. It should start from zero and raise gradually, as the stop-valve at the boiler is opened, until it remains stationary. It may not register the correct pressure then; if more steam is called for by the

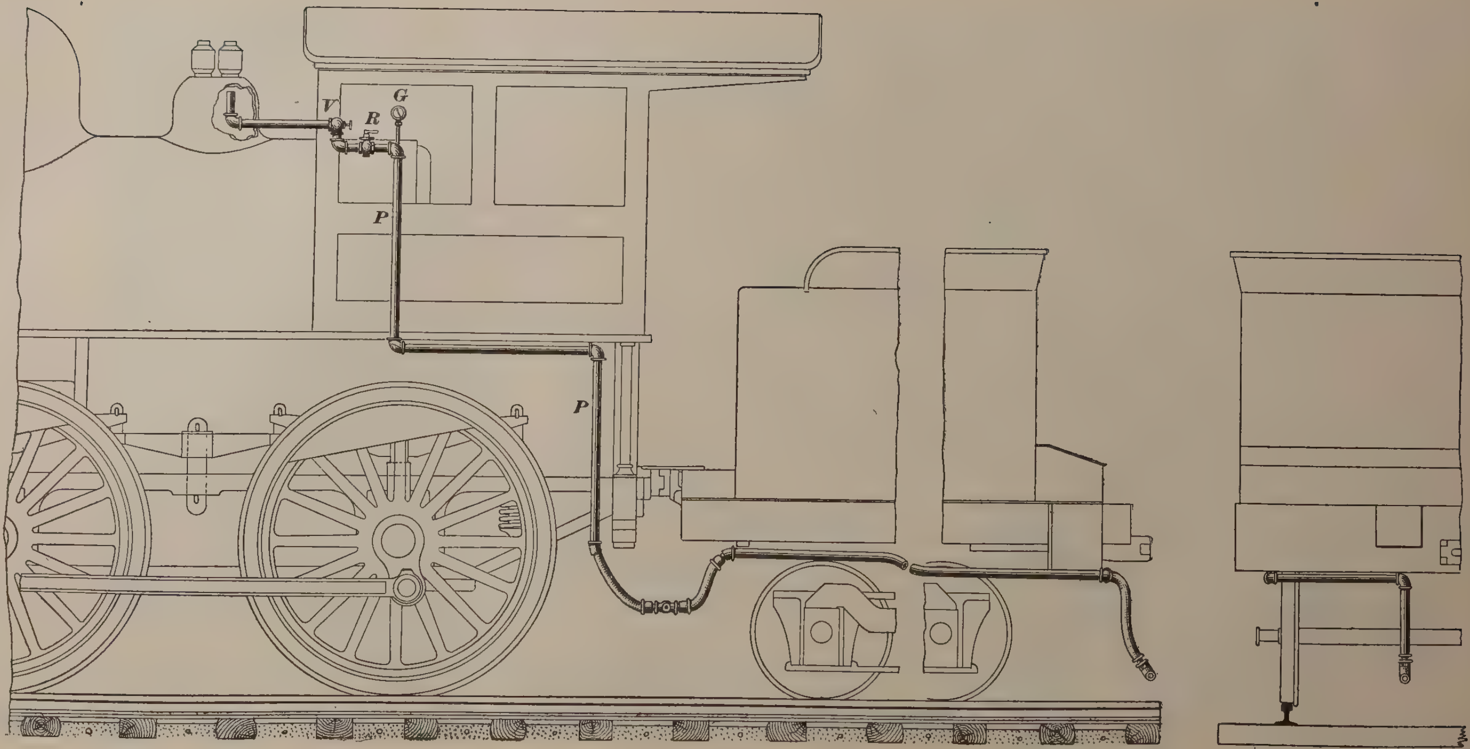



FIG. 6

trainmen, turn on more until the circulation is established in the cars, when the pressure can be reduced. About 60 pounds in the hose will usually cause the couplers to raise up and leak steam.

## THE GOLD SYSTEMS

### GENERAL SCHEME

**25.** In the Gold Company's systems, the steam supply is regulated by a valve under control of the engineer. The main piping, called the *train pipe*, runs centrally underneath the cars, the connection between the cars being made by hose couplers. From this pipe each car receives its supply of steam, which passes into a system of piping running near the floor on each side of the car.

### ENGINE EQUIPMENT

**26.** Fig. 6 shows the arrangement of the engine equipment. Steam is usually taken from the dome of the boiler, as shown, the supply being controlled by the angle valve *V*, the pressure regulator being shown at *R*. Gauge *G* indicates what steam pressure the regulator is delivering to the train. From the regulator, the steam is carried by suitable piping *P* to the rear of the tender, where it connects with the train pipe.

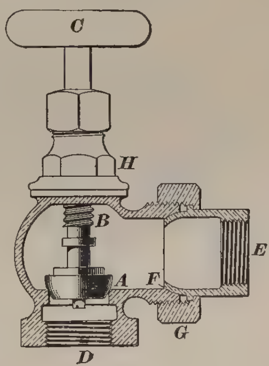



FIG. 7

**27.** **Stop-Valve.**—In Fig. 7 is illustrated the **stop-valve** used in connection with the Gold system of train heating. It is an ordinary hard-seat valve, and needs but little description. By means of this stop-valve, the engineer can shut the steam off altogether from the train when not being heated.

**28.** **Pressure Regulator.**—Fig. 8 shows a sectional view of the **pressure regulator**. Steam from the boiler

enters at $A$ and leaves at $B$, the connection being made by heavy brass unions $U$. The valve that controls the passage of the steam consists of the disks $a$ and $b$ carried on the

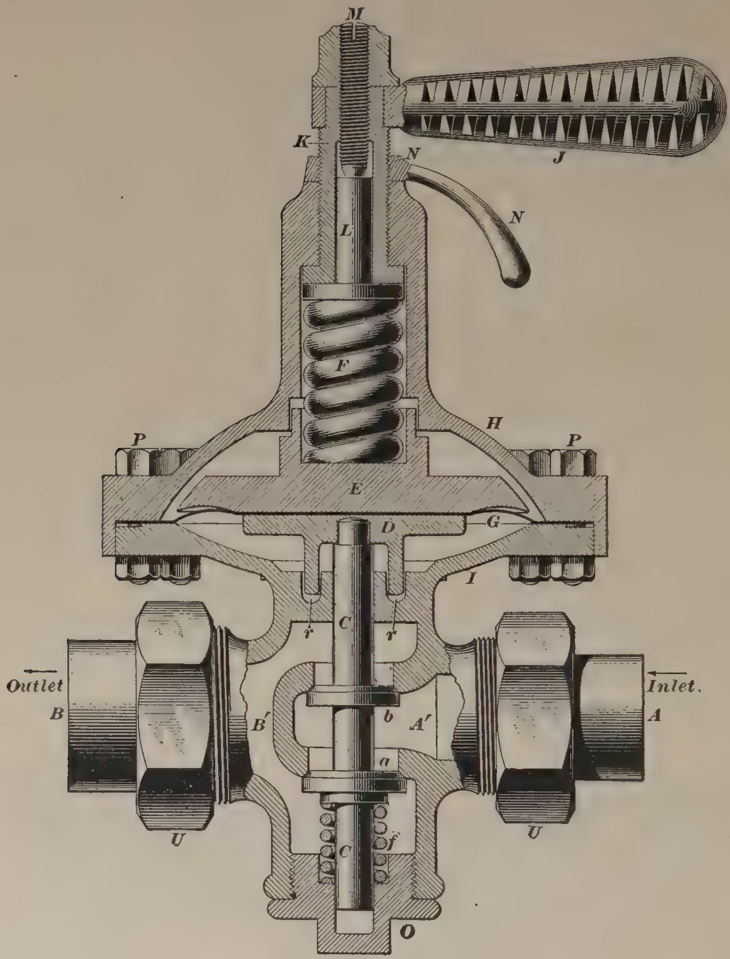



FIG. 8

spindle $C$. This stem is pressed down by the spring $F$ acting on the flanges $E$ and $D$, between which is the diaphragm $G$, the outer edge of which is secured between the dome $H$

and body $I$ of the regulator, as shown. This diaphragm is a solid sheet of special metal; provision is made against any undue straining of it by widening the flange $E$, so that the diaphragm always maintains practically its original condition. The recess $r$ provides a water seal and thus prevents chattering.

The regulating is done by means of the handle $J$. When this is turned around, the hollow screw $K$ moves up or down, and with it the top spindle $L$, thus relaxing or tightening up the spring $F$. When once set for the proper pressure, the handle $J$ is locked in position by the nut and handle $N$. The setscrew $M$ can be screwed in or out independently, and serves for a check on the maximum or minimum pressure required, for it can be set to control the movement of the spring $F$ by coming in contact with the top of spindle $L$. The bottom plug $O$ helps to guide the spindle $C$, and the lower spring $f$ keeps the valve $a\ b$ closed except when handle $J$ is screwed down to open it; this spring also makes the valve respond promptly to the movements of the diaphragm.

Suppose that the boiler pressure is 200 pounds, and that it is required to supply steam of only 30 pounds pressure. On the steam being admitted into $A'$, it finds the valve $a\ b$ closed, that being its normal position—due to the thrust of spring $f$ as already explained. By now turning the handle $J$ from right to left, the valve $a\ b$ will be opened, and steam will flow into $B'$ and so on through $B$ into the train system, raising the pressure therein to the desired amount, as indicated by the steam gauge. The steam in $B'$ also passes up to the under side of diaphragm $G$ and flange $D$, tending to force these upwards. As soon as the steam in the train system and chamber $B'$ has risen to slightly above 30 pounds pressure, the pressure of the steam underneath the flange $D$ and the diaphragm $G$ moves them upwards against the force of spring $F$, the valve following being pushed by spring $f$. If, now, more pressure were required in the train, the spring $F$ would have to be screwed down so as to increase its thrust, and hence the steam from $B'$ would not force up

the diaphragm and allow the valve to close until it had reached a higher degree of pressure. Suppose, now, that the steam in the boiler fell to, say, 170 pounds; this would not affect the pressure in $B'$ and the train, for the latter pressure would not allow the valve to close until it had attained the required degree—say 30 pounds.

The regulator is opened by turning the handle *J* from right to left, and when opened to the proper amount, it can be secured in that position by the device *N*. The regulator must not be used as a stop-valve; that is, for the purpose of shutting off the steam from the train entirely. The angle valve shown in Fig. 7 is provided for that purpose. The regulator is intended for the purpose of reducing the boiler pressure to the proper pressure required in the train, and this is done by turning the handle *J* until the pressure on the outlet side $B'$ is of the proper amount, as shown on the gauge provided for that purpose. If more pressure is required on the train, the handle *J* must be screwed farther down; that is, turned from right to left. If less steam pressure is required, the handle should be turned in the opposite direction, namely, from left to right; when the proper position is reached, lock it there by means of *N*.

The valve stem *C* may be withdrawn occasionally for inspection and cleaning. To do this, ease the pressure of the spring *F* by turning the handle *J* from left to right, take out the bottom plug *O*, and then withdraw the stem. See that the spring *f* is clean and working properly on the stem, and also that the recess in *O* is clean. By taking off the nuts *P*, the dome *H* may be removed and the parts inspected, attention being paid to the recess *r*. In case any part of this valve becomes disabled so that the steam from the boiler will not pass into the train pipe, take off bottom plug *O*, as already described, take out valve stem *C*, replace plug *O* and regulate the pressure by the stop-valve shown in Fig. 7.

**29. Hose Couplers.**—Fig. 9 (*a*) shows a set of **hose couplers** connected up in position on the train. View (*b*) shows the manner of coupling up, and is a view of the

couplers from above, showing them in the act of being brought together, the two gaskets *g* just coming in contact. If either of these gaskets leaks, the defective one can be pulled out with a small hook and a new one put in its place. This hose coupler is provided with a *gravity relief trap*, the trap as a whole being in a horizontal position when the hose are coupled up. When steam first passes into the coupler, it acts on the baffle plate *t* of the trap, Fig. 13, and forces the valve up against its seat, preventing any escape of steam. As soon as the steam pressure is released, the weight of the baffle plate causes it to fall, tilting the valve as shown, thus opening the trap and releasing all water from the coupler.

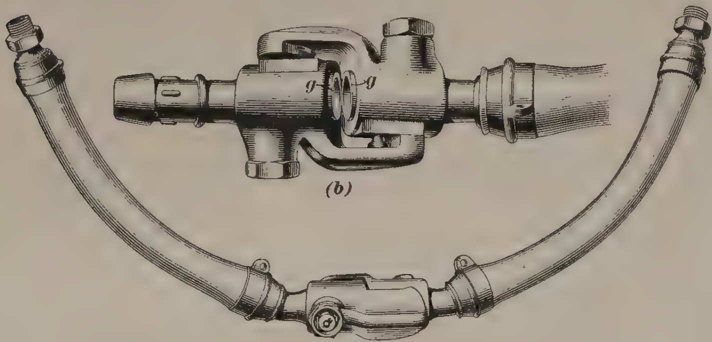



FIG. 9

When steam is again turned on, it again closes the valve. The use of such a trap obviates the necessity of uncoupling the cars when laid up or when steam is not in use on the train.

---

### CAR EQUIPMENT: DIRECT STEAM

**30. General Description.**—Fig. 10 shows a plan of a car floor, in perspective, in which direct, or straight, steam is used. Steam is taken from the train pipe *P* by means of the train-pipe valve *V*, which can be operated from either inside or outside the car. As seen in the illustration, this valve is attached to the train pipe underneath the car, and as a rule in about the center of the car's length. At one side of

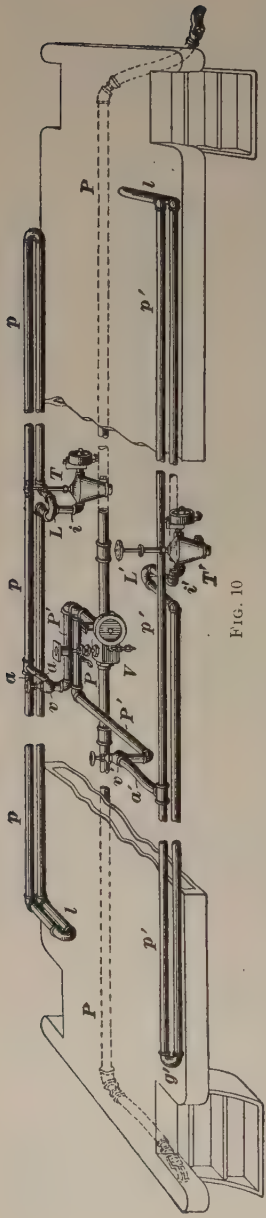


FIG. 10

this valve is a short nipple through which steam passes into the pipes $P'$ that lead to the valves $v$, $v'$. From the side outlet of each of these supply valves runs a length of pipe $a$, $a'$ that connects, by means of a **T** piece, with the two courses of piping $p$ and $p$ that constitute the radiating surface for heating the interior of the car; these pipes run alongside the truss planks on either side of the car. At one end of each course of piping is a loop $l$, which provides for the expansion or contraction of one of the pipes of a pair relative to the other. The lower pipe of each pair is formed into a loop $L$ at about the center of the car, a special return bend with side outlet being used to connect with the short vertical drain pipe $i$.

The pipes are placed with a slight pitch so as to enable water to find its way to the traps $T$ and $T'$; these are placed under the car, one on each side. To protect the dresses or feet of passengers from coming in contact with the hot pipes between the seats, shields are placed over them.

The two sides of the car are independent of each other as regards their heating; each side has its own steam-supply valve and its own steam trap; thus the heat on either side of the car is easily regulated. The supply valves are generally in the center of the car's length at the end of the seats, close to the aisle, so that they can be readily operated without disturbing the

passengers. In this and following systems, the piping, valves, etc. on the two sides of the car are for the most part identical; our explanations, therefore, while alluding only to the one side, yet apply equally to the other.

**31. Train-Pipe Valve.**—The train-pipe valve, used for controlling the supply of steam to the individual car, is shown in Fig. 11 (*a*). The part marked *a* is the valve body, inside of which is a valve that is operated from inside the car by the socket *b*, the floor plate *c* having marks thereon to act as a guide to the valve's position; *d* is the spindle that actuates a cam or eccentric that works inside the piston valve contained inside the body *a*. This spindle has a square fit inside the socket *b*, and is also held by the setscrew *f*; the spindle *d* can be turned around by means of the handle *g*, which is fastened to the flange sheave *h* by a setscrew. The sheave spring *j* is held in the arm *k* and engages with a slot in the edge of *h*. The spindle *d* can also be turned by inserting a key in the top of the socket *b*, the key being shown in view (*c*); a downward thrust displaces the plug *l* against the resistance of a spring *s* inside *b*, view (*a*), and then the socket, and with it the spindle *d*, can be rotated. The connection with the train pipe is made by means of the union coupling *n*. Any condensation is taken care of by the steam trap attached to the side of the valve body, and so water is prevented from backing up into the piping, where it could freeze and burst the pipes. The purpose of the train-pipe valve is to shut off the steam at the train pipe from all cars in the rear of that particular valve; it is not intended as a means of shutting off steam from its own car, as it would also shut it off from all cars behind it. The steam is shut off from a certain car by using the steam valves *v*, *v'*, Fig. 10. When changing engines, the valve can also be operated so as to shut in the steam already in the train.

**32. End Train-Pipe Valve.**—The end train-pipe valve, Fig. 12, is constructed on the same principle as the ordinary standard valve shown in Fig. 11, and is opened and closed

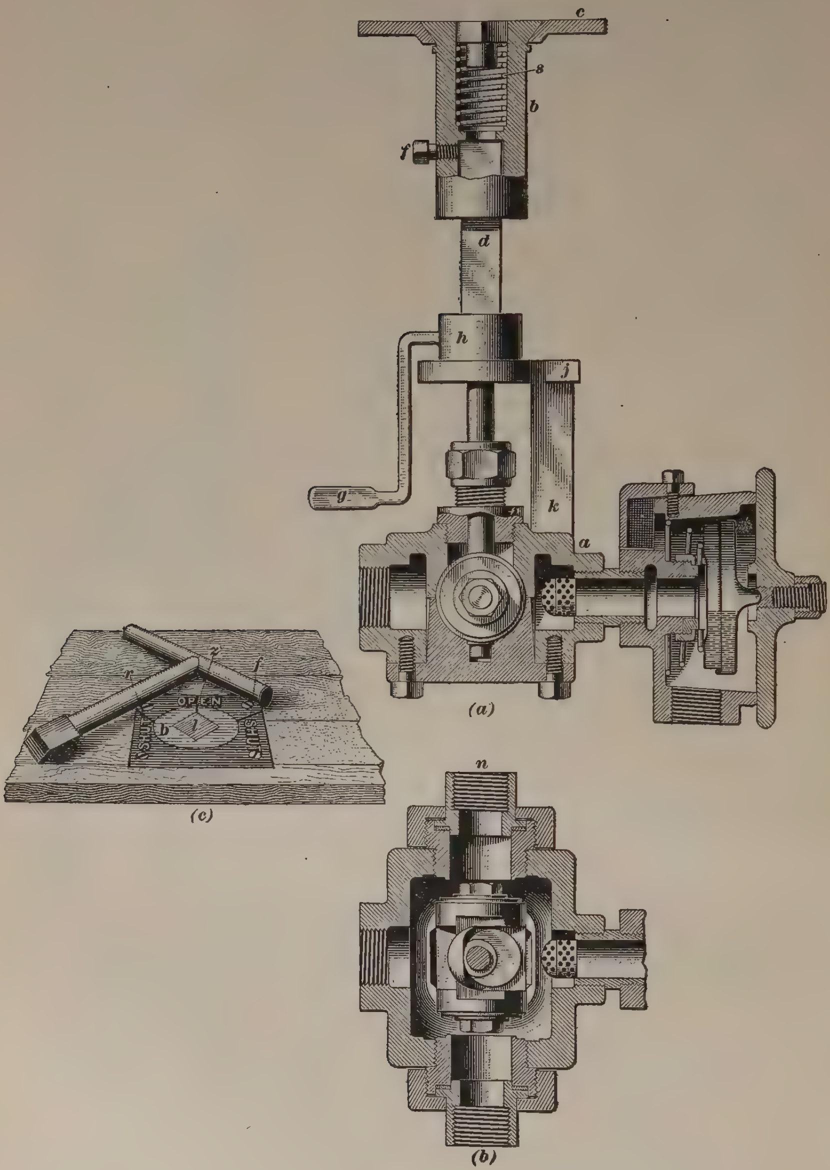



Fig. 11

by means of the cam arrangement therein used. It is fitted with a drip opening to prevent freezing. The drip hole, about $\frac{1}{8}$ inch in diameter, is not shown in the figure, as it is on the far side of the valve body, as viewed in the figure.

**33. Automatic Steam Trap.**—It is of the utmost importance in a steam-heating apparatus that suitable provision be made for disposing of the condensed steam, so as to prevent the system from freezing and giving trouble through bursting pipes. For this purpose an **automatic**

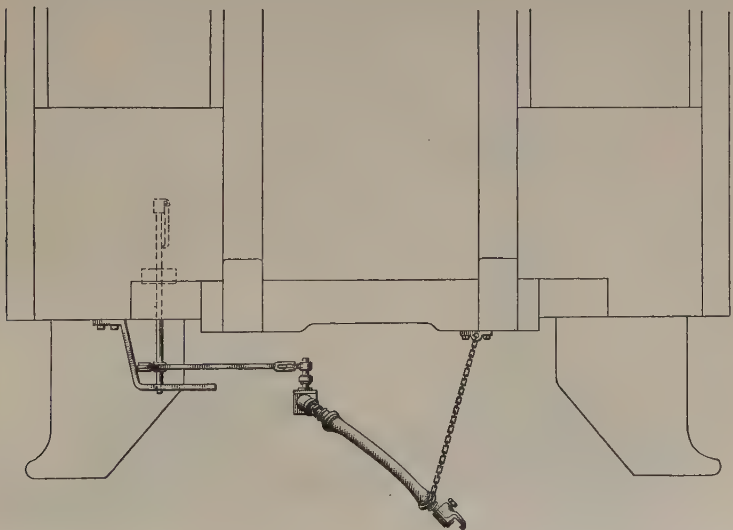


FIG. 12

**steam trap,** Fig. 13, to which is attached a sediment well and a gravity relief trap, is used with this system.

This apparatus is placed at a convenient point behind the car trucks and is connected with the drip from the heaters in the car. In the figure, *a* is the body of the trap; *b*, its cover; *c*, the composition seat with which, under certain conditions, the diaphragm *d* comes in contact, being held there against the push of the spring *e*. The diaphragm is held in position by several ribs or lugs *i* in the interior of body *a* and also

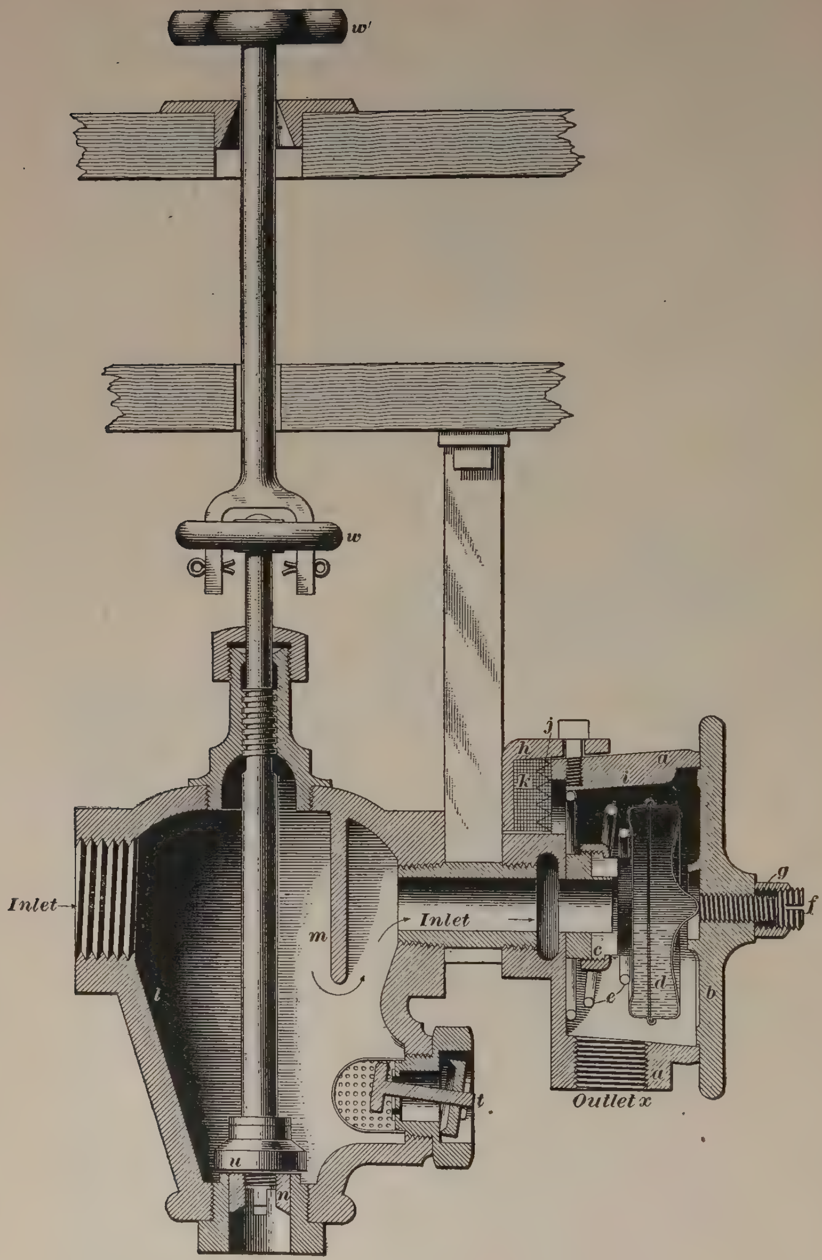



FIG. 13

by the setscrew $f$, which is secured where required by the locknut $g$. One rib is directly opposite the outlet, and so is shown cut through.

The ventilator $h$ is for the purpose of keeping the trap cool; the interior of the trap communicates with the atmosphere through the notched openings $j$, a piece of gauze wire $k$ being placed inside, as shown, to serve as a strainer. The inlet and outlet are as marked.

The interior of the diaphragm $d$ is partly filled with an expansive fluid, which is very susceptible to changes of temperature, expanding and contracting as the heat in the trap rises or falls. When it is required to clean or repair this trap, remove the cover $b$, which locks by means of its lugs engaging with the inclined flanges, not here shown, on the body $a$; a quarter turn will remove the cover, and the same amount will lock it tightly in position again.

When the trap is cold, the fluid within the diaphragm contracts and the diaphragm occupies the position shown in the figure, thereby enabling the spring $e$ to force it from its seat $c$. When all the condensed water has been discharged and live steam comes in contact with the diaphragm, the latter is caused to expand and thus come in contact with the seat $c$, thereby closing the trap and preventing a waste of steam. As condensation continues, and the water thereby formed gets colder, the trap again cools, the fluid within the diaphragm contracts, and the diaphragm is again moved to the position shown, allowing the condensed water to pass off through the outlet $x$. When used for draining off the condensation from the heaters within the cars, this trap is provided with a sediment well having a gravity relief trap $t$, attached as here shown. The duty of this sediment well $l$ is to retain any dirt that might otherwise be carried into the trap and clog up and impair the seat. The partition $m$ is so located as to intercept the dirt, which drops to the bottom of the well. The sediment thus collected should be blown out two or three times during the winter. This may be done by opening the valve $u$ by turning either handle $w$ or the handle $w'$ operated from inside the car, according as to

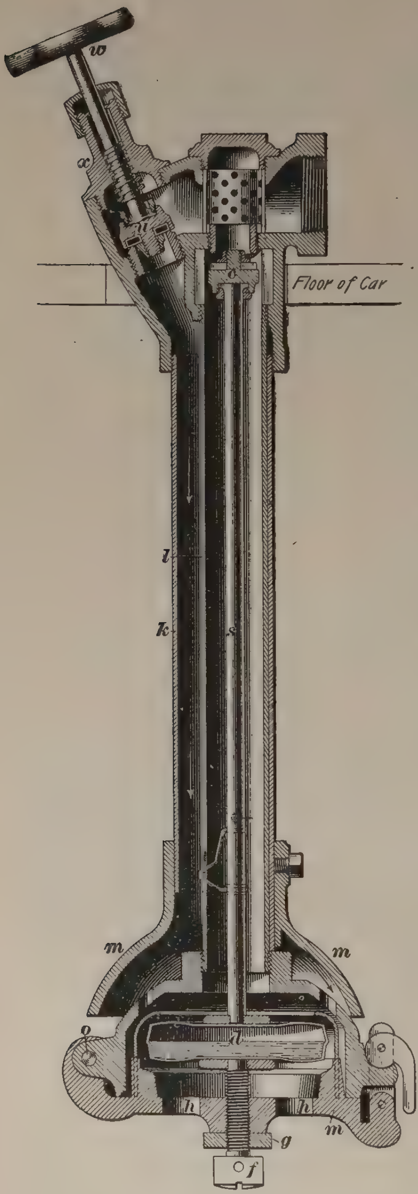


FIG. 14

which is most convenient. This valve $u$ is provided with a composition seat; when closed, it screws down on the threaded brass plug $n$, which forms a seat for it.

**34. Vertical Steam Trap.**—When it is found desirable to use traps that shut off the condensed steam within the car body, the trap shown in Fig. 14 is used. The trap is placed in a vertical position, with the cast-iron trap head, which contains the automatic valve, inside the car, the body of the trap extending through the floor, as shown; the expansion device is at the bottom of the trap, and when the latter is placed in position in the car the upper part of this device comes inside the car. The amount of expansion that must take place before operating the valve is adjusted by means of the screw $f$ and the locknut $g$; this is usually regulated at the terminals. The blow-off valve $w$ is provided so that when so desired this apparatus and

the heating system may be quickly relieved of pressure or of condensation. The valve may be removed by unscrewing the bonnet *x*. The trap is provided with a hinged cover *m*.

The action of the trap is as follows: When steam is shut off, and the trap is therefore not in operation, the diaphragm *d* is in its contracted condition; that is, has shrunk to its smallest bulk, and the valve *c* therefore has fallen from its seat. When steam is turned into the heating pipes, the water that is in them is released through the valve and flows down and out through the openings *h*, *h* in the bottom of the trap. As the temperature of the outflowing water increases, the liquid in the diaphragm *d* is heated and expands, causing the diaphragm to swell and thereby raise the rod *s* that pushes the valve *c* up to its seat. The flow of hot water on the diaphragm thus being shut off, the liquid in the diaphragm cools again, and so allows the walls to come together, thus letting the valve rod *s* fall and release the valve *c* from its seat, permitting the escape of the condensed water that has meanwhile accumulated.

**35. Operating the System.**—1. *Working the Train-Pipe Valve.*—In Fig. 11 (*c*) is shown a plan view of the floor plate *c*, showing also the top of the socket *b*. A groove *z* is cut in the upper surface of the socket, and three others in the floor plate. The valve is moved by rotating the spindle *d*; the socket and spindle move together. Hence, when the valve moves, its positions are indicated to the trainmen by the position of groove *z* relative to the grooves in the floor plate. The front and rear of train being as here shown, we will allude to the two "shut" grooves as *f* and *r*, respectively. Then, if it is desired to shut off steam from the cars in the rear of the one whose train-pipe valve we are supposed to be operating, or if this is the rear car, groove *z* must be brought in line with groove *r*. If steam is required to pass through to the rear cars, *z* will stand as in Fig. 11 (*c*), in line with the "open" groove.

When it is desired to retain the steam in the train, as, for instance, when engines are being changed, the groove *z* on

the first car must be brought into line with the groove *f*, the groove nearest the engine. When turning the indicator toward the word "shut" in either direction, turn it as far as it will go, even if it should thereby go past the groove. The letters *z*, etc. are not on the actual apparatus; they are used here merely for convenience of reference.

2. *Heating a Cold Train.*—First see that the hose are properly coupled between all cars and to the locomotive and that the train-pipe valves are open on all cars. It is advisable, although not strictly necessary, to have all the steam valves under the seats closed, except those in the rear car. This being done, let a good pressure of steam—say 50 to 75 pounds—blow through the train pipe until it shows at the rear car. Next open the steam valves under the seats from the rear of the train toward the engine, and then tell the engineer to reduce pressure. When once the pipes in the train have all been filled with steam, from 10 to 20 pounds pressure on each car will ordinarily be sufficient to keep them perfectly warm.

3. *Regulating the Heat.*—To regulate the heat in moderate weather, or whenever necessary, close one or both of the steam valves under the seats. These steam valves should always be open at least three turns, or else be closed tight. Shutting off the heat in any one car does not affect the heat in any other car. Whenever a car is cut off from the train, all valves should be left wide open.

4. *Coupling Up and Uncoupling Cars.*—When coupling the hose of two cars together, it is advisable to tip the coupler bodies up evenly, so that both sides shall lock at the same time and the gaskets come up fair against each other. When uncoupling the hose by hand, pull the coupler bodies straight up in the middle, where they join together.

5. *Operation When End Train-Pipe Valves Are Used.* When about to heat a cold train, see that all hose is coupled, and that all train-pipe valves are open, and then send a good pressure through the train. When it blows out strong at the rear, close the rear train-pipe valve, allowing a slight escape of steam.

Regulate the heat, according to requirements, by the steam valves, as already explained. The blow-off valve on the trap should always be closed when the supply valve is open. After the pipes in the cars are filled with steam, the pressure from the engine may be reduced according to length of train and state of weather.

When approaching a terminal where the engine is to be cut off, open the rear valve and signal the engineer to shut steam off from the train.

---

### CAR EQUIPMENT: HOT WATER

**36. System 1.**—In this system, the heating is done directly by hot water that is heated by steam from the engine in a Baker heater *S*, Fig. 15. A compound, or duplex double-pipe, coil, however, is placed in the heater instead of the regular Baker coil. This duplex coil is made up of two 2-inch pipe coils *A* and *A′*, inside each of which is a coil of ¾-inch pipe, as shown in Fig. 15, where part of the heater casing *S* is shown removed so as to expose the coils to view, the pipes composing the larger of which are also shown partly broken away, exposing the ¾-inch inner coils. These coils are fitted at the ends with special **T** pieces *t*, *t′*. In the upper openings of the **T** pieces *t* are screwed the pipes *R*, *R′* that lead to the expansion drum *D*, while the lower **T** pieces *t′* connect with the hot-water pipes that run around the car.

The course of the steam is as follows: Steam is taken from the train pipe *P* at the train valve *V*, which is situated underneath the car, passing thence through the pipe *P′* to a point near the top of the heater *S*, where it makes connections with two steam valves *v*, each of which controls one of the ¾-inch pipe coils that are inside the 2-inch coils *A*, *A′*. From the upper side of the **T** pieces *t*, *t* run the hot-water risers *R*, *R′* that enter the sealed jet fittings that are connected, at their upper sides, to the expansion drum *D*. Hot-water outflow pipes *p* and *p′* run from the bottom of these sealed jet fittings. These fittings, which are called accelerators, are shown in section in Fig. 15 (*b*). When the hot

water rises, it enters the sealed jet at the inlet, passes around through the bend, and, owing to the taper of the nozzle, is forced downwards into the pipes $p$, $p'$, with considerable energy. Any air that may be mingled with the water will rise to the expansion drum, through the $\frac{1}{8}$-inch hole in the bend of the nozzle. These pipes $p$, $p'$, one to each coil, take a course right around the car, as shown by the arrows, coming back to the bottom of the coils in the heater $S$, the connection being made with the 2-inch pipes by means of the **T** pieces $t'$, $t'$; $s$, on top of drum, is the safety valve to relieve excessive pressures, view $(c)$.

Water is contained in the coils between the inner and the outer pipes, and is heated by steam passing from the train pipe $P$ through valve $V$ into pipe $P'$, and so to the inner coils. Steam enters at the top, circulates through the two small coils, passes out at the bottom into the drip pipes $i$ and $i'$, and thence along to the steam traps $T$, $T$ underneath the car; from these traps, is drained off all the condensation that comes to them from the two inner coils.

It will be seen that this system of piping provides the power of two Baker heaters with only one stove and one expansion drum, and also that each side of the car can be controlled independently of the other. In this manner the heat can be very satisfactorily regulated, as in mild weather only one side of the car need be heated, while in severe weather the double circulation can be called into service and both sides heated.

When the pipes in the heater $S$ are filled, the water fills the space between the inner and outer coils of pipe; therefore, when fire is used in the stove, the water is heated by the fire coming in contact with the outer pipes of the coil, and it will circulate in the way described, with the additional advantage gained from the use of the sealed jet. When steam is used, the water is heated by the steam contained in the small inner pipes—the $\frac{3}{4}$-inch coil.

**37.** To heat a train, pass a high pressure through the entire train until steam blows out at the rear; then close the

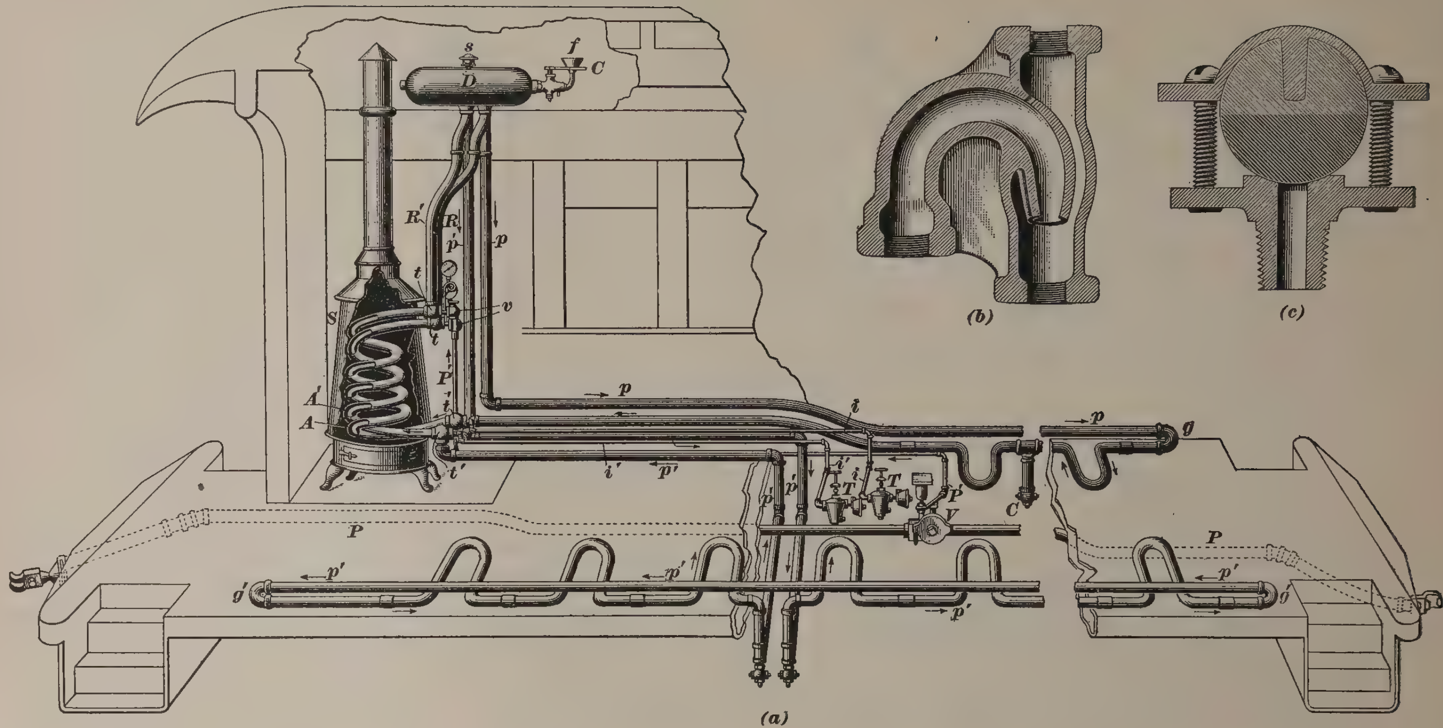



FIG. 15

rear train-pipe valve and open the globe valve at the heater. When working this globe valve, remember to always open it wide and close it tight, respectively. The pressure gauge at the stove should show from 10 to 40 pounds of steam, according to requirements as dictated by the weather. Whenever steam is being used in a car, hot water should escape from the steam trap under that car. If it appears that the trap does not let the water out freely enough, open the blow-off valve inside the car by turning the handle $w'$, Fig. 13, or $w$, Fig. 14, just sufficient to let the water escape freely without blowing steam. By doing this, dry, hot steam can be retained in the pipes and increase the heating power of the coils in the heater.

Either fire or steam can be used in connection with this system, or both used together. If, in severe weather, steam must be turned off for more than about an hour, a small fire should be built in the heater to prevent the water freezing.

When using a fire in the heater, care should be taken not to choke it up with too much coal. The stove should never be more than half full; if filled up more than this, the heating will be retarded instead of helped. This being what is called a *closed* circulation, that is, not open to the atmosphere, the pipes should be filled with a strong solution of salt water, this having been found to be best for the purpose. Each side should be filled separately. Instructions for preparing the brine and filling the system have already been given.

**38. System 2.**—Another method of hot-water heating sometimes used is illustrated in Fig. 16. It is very similar to the circulating system already illustrated in Fig. 15, differing therefrom principally in having only a single supply valve and trap, but having two expansion drums instead of one. Other differences in the equipment will be evident from the figure.

In this system, also, $P$ is the train pipe and $V$ the train-pipe valve, whence the steam passes through $P'$ until it reaches valve $v$. There is in this case, as just remarked, only one valve $V$ and also only one valve $v$, instead of two,

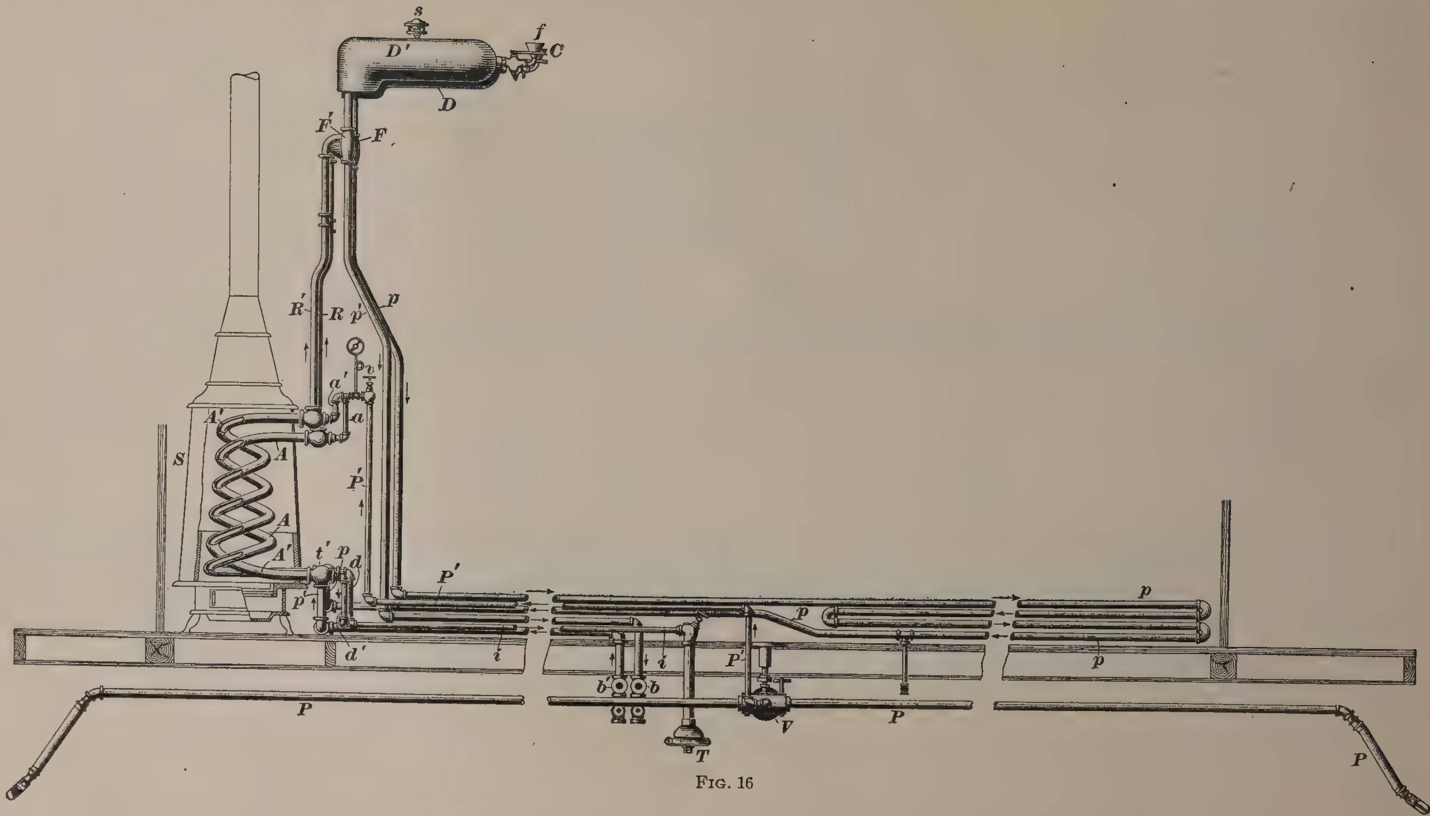



FIG. 16

as in Fig. 15. When the valve $v$ is opened, steam passes into both the inner coils in the heater $S$, through the two pipes $a$, $a'$. The water is heated in both coils simultaneously, and the condensation goes down the pipes $d$, $d'$ and is carried off through the pipe $i$ to the trap $T$. The risers $R$, $R'$ pass up to the sealed jets $F$, $F'$, as in Fig. 15, but each pipe goes to its own expansion drum in this case, instead of both going to the one drum. From the sealed jets, run the pipes $p$ and $p'$. In the illustration, the car is supposed to be broken in two places, and the end portions brought close together, thus showing the apparatus on a larger scale than would otherwise be possible. The course of hot-water pipe $p$ is readily traced; it runs to the end of the car and makes the return bends shown, and then comes back to its **T** piece $t'$, by which it enters the 2-inch coil at the bottom of the heater. The pipe $p'$ takes the course shown, turns downwards to the cross-over $b$, and passes to the other side of the car, returning thence through the other cross-over $b'$, as shown by arrows, and so to its **T** piece and into the bottom of the other 2-inch coil.

When fire is used in the heater, the outer surface of the large coils is in contact with it and so these are heated up, the result being the same as when using steam.

---

### CAR EQUIPMENT: STEAM STORAGE

**39.** In the **direct-steam, terra-cotta, storage-heater equipment,** illustrated in Fig. 17, the pipes are arranged practically the same as in Fig. 10, except that after the lengths $a$, $a'$, leading from the train-pipe valve $V$, have passed the steam valves $v$, $v'$, they couple into a loop, as shown, from which loop the pipes $p$ branch off on one side of the car and $p'$ on the other. These pipes run into the storage heaters $S$, $S'$, of which there are four in a car. This storage heater is an iron pipe, usually a 5-inch iron tube, inside of which are terra-cotta bricks; these are about 12 inches long, and are a snug fit. The two lengths of pipe $p$ are not continuous as in Fig. 10; instead, the upper

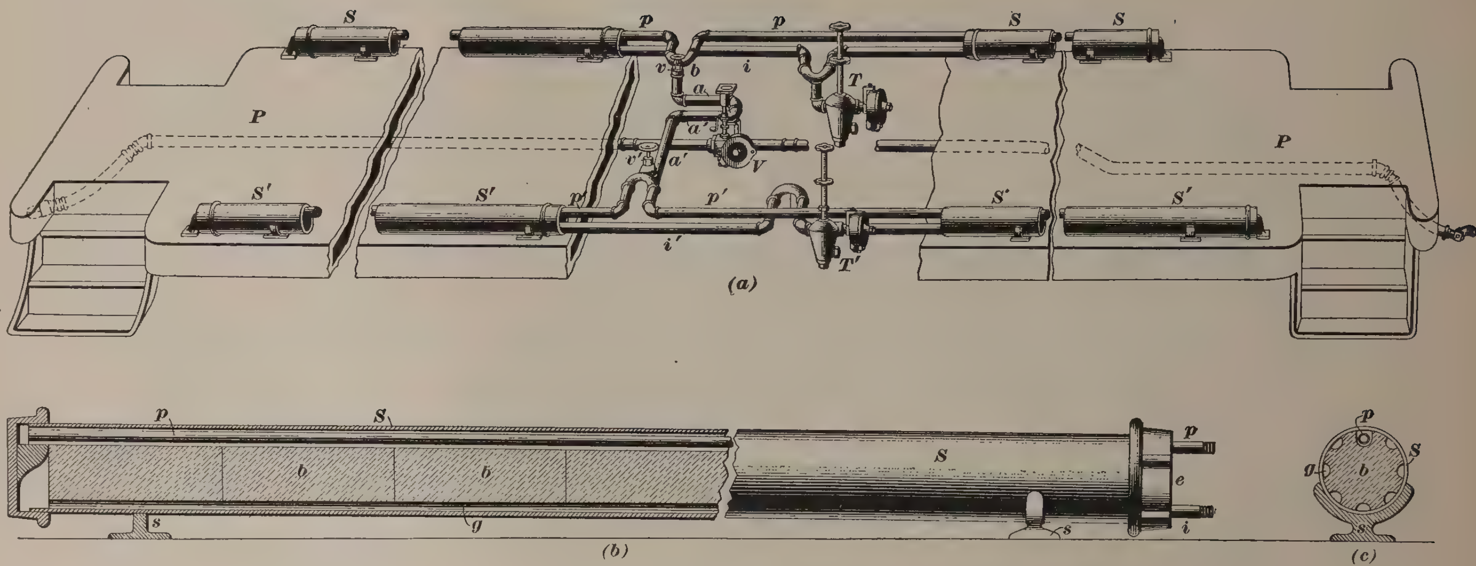



FIG. 17

length stops short at the far end of the heater, as shown in view (*b*), which is a section of one of the heaters drawn on a larger scale. The tube or pipe *S* is shown in section in the left-hand portion of (*b*), the bricks *b* being shown in position, together with pipe *p*, the whole being supported on the stands *s*. View (*c*) is a cross-section of the heater showing the grooves *g* in the bricks *b*. The heaters are set with a fall toward the center of the car, as shown, so that any condensation may the more readily draw down to the end *e* and so out of pipe *i* into the trap *T*, which is of the same design as that in Fig. 10. These heaters are placed close to the truss planks, shields being provided between the seats, as in the heating systems already described.

Steam passes from the train pipe through the pipe *a*, past the valve *v*, and thence through pipes *p*, *p* to each of the heaters on that particular side of the car. It passes out of the pipe *p* into the heater and then returns through the grooves or corrugations *g*, passing out of the heater by pipe *i*, and so on to the trap *T*. In its passage through the heater its heat is absorbed by the bricks, which have the property of taking up a considerable quantity of heat; this heat is then given out and diffused throughout the car. Each side of the car has a separate system; this requires two steam pipes and two steam valves.

# CAR HEATING

(PART 2)

## HEATING BY STEAM—(Continued)

### THE SAFETY COMPANY'S SYSTEMS

**1.** The Safety Company uses several systems of heating cars by steam, each of which will be described in turn. The main scheme is the same in all, the steam supply being taken from the locomotive and passed along a train pipe running underneath the cars the whole length of the train, train-pipe connections under each car allowing the steam supply for that car to be taken from the main pipe.

### ENGINE EQUIPMENT

**2.** Fig. 1 shows the arrangement of the engine equipment. Steam is taken through a dry pipe $p$ in the interior of the dome, as shown, the pipe opening into the highest point of the dome and leaving the back head of the boiler at the point $a$. The valve $V$ controls the steam supply from the boiler. $R$ is the pressure regulator that regulates the pressure to the train. A pressure gauge $G$ is connected with the train-pipe side of the regulator, and thus indicates the steam pressure on the train. The pipe $P$ runs to the rear end of the engine, where it receives the union $u$. Connection is made here with the steam coupler $C$, which in turn connects with the pipe $P'$ that runs to the rear of the tender and is fitted with a steam hose $C'$. Its rear

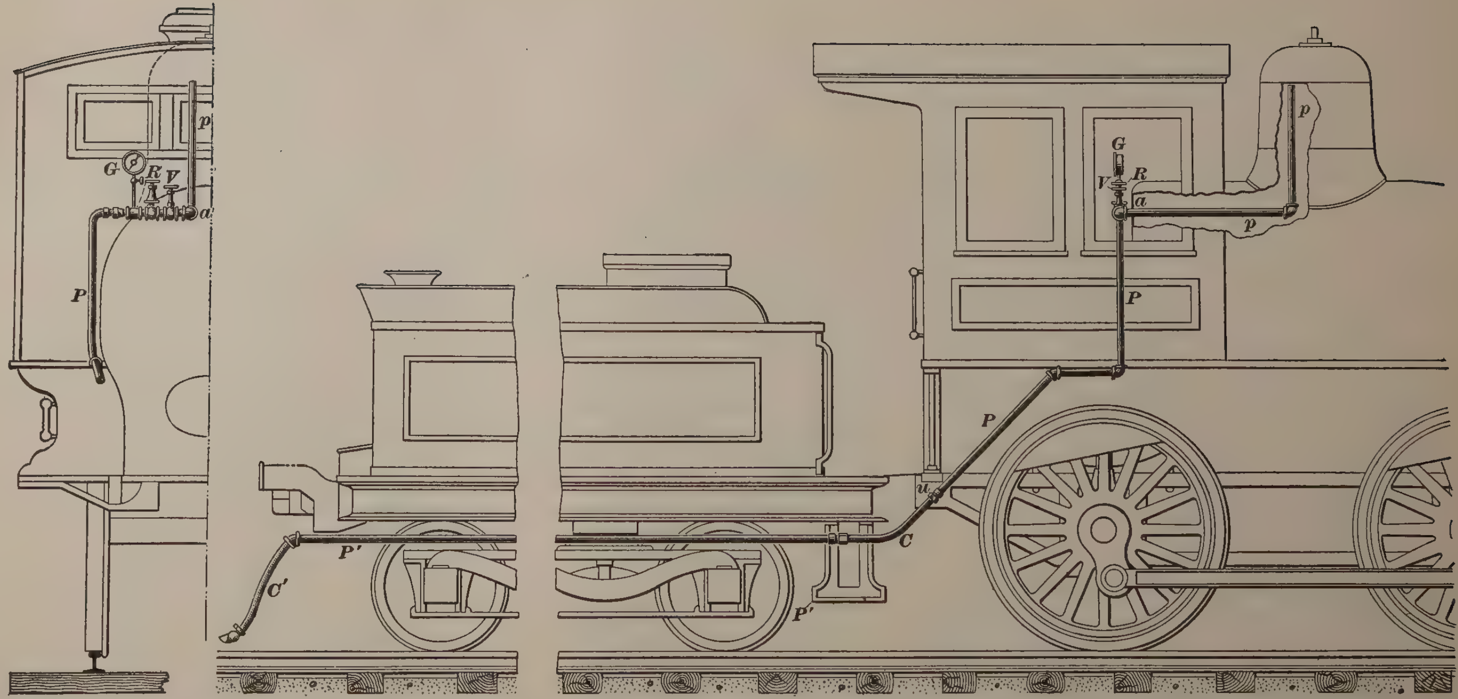



FIG. 1

end is 12 inches from the center line of tender and 33 inches above top of rail.

**3. Stop-Valve.**—The stop-valve included in the engine equipment is illustrated in Fig. 2, which shows the valve in section; the bonnet *H* is secured to the body of the valve by the screws *I*, instead of being screwed into the body.

**4. Pressure Regulator.**—In connection with trains heated with this system, the locomotive is supplied with a Mason reducing valve for the purpose of reducing and regulating the pressure of steam supplied to the train. A section of this valve is shown in Fig. 3. Steam from the boiler enters at *A* and passes out at *B* into the train system, the connections being made by the unions shown. The steam passes into *B′* through the main valve *C* when the latter is raised by piston *D*, which is moved upwards by the steam that comes through port *p′* when the auxiliary valve *c* is moved down (that is, opened) by the force of spring *F*, this valve *c* remaining open as long as the pressure in *B′* is below a certain amount. The port *p′* passes around behind chamber *A*.

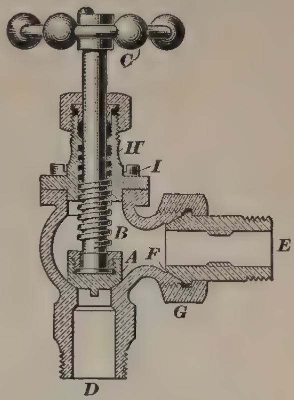


FIG. 2

When steam first enters at *A*, with no pressure in *B*, it finds the auxiliary valve *c* open, as just explained, and so passes by that valve and goes up port *p* and down port *p′* into the space underneath piston *D*. We now have boiler pressure acting on main valve *C* and also on piston *D*; the latter having twice the area of *C*, steam pressure forces it up and forces *C* open against resistance of spring *H*, thus letting steam pass into *B′* and on into the train system. The steam in *B′* also passes up port *q* and acts on diaphragm *G*. When the pressure in the train, and therefore in *B′*, has reached the desired amount, diaphragm *G* is forced up against the resistance of spring *F*, thus allowing the steam in *A′*

to close the auxiliary valve $c$ and thereby shut off the steam from ports $p$ and $p'$. Boiler pressure is thus shut off from underneath piston $D$, but still acts on top of valve $C$, which it therefore closes, and in doing so shuts off live steam from

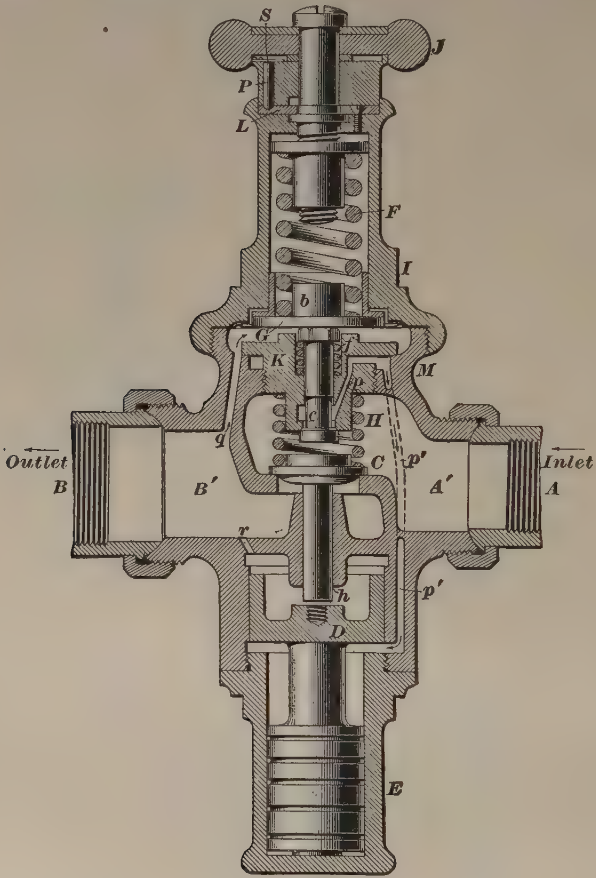



FIG. 3

the train system. When valve $C$ closes, it forces piston $D$ downwards; the steam that is trapped in beneath this piston exhausts through port $r$ and passes on into the train system, the piston being purposely made a loose fit. This piston is provided with the dashpot $E$ so as to prevent chattering or

pounding when the pressure is suddenly reduced. The springs *H* and *f* assist in making the action of valves *C* and *c* more prompt, tending always to keep these valves on their seats.

The regulator is opened by turning the wheel handle *J* in the same direction as if one were unscrewing a nut; namely, from right to left. This wheel may be held in any one of twelve positions by the pin *P*, which drops into one of twelve recesses in the plate *L*, being forced into the recess by the spring *S*, which is held in position by the small screws shown. Time must be allowed for the train system to fill up to the required pressure.

If the regulator will not maintain a low pressure, it is probably due to a leaky valve *C* or to dirt on the seat of the valve. When about to take the regulator apart, relieve the tension on the diaphragm spring *F* by screwing the wheel handle in the same direction as when tightening up an ordinary nut. Then unscrew the spring case *I* and remove the button *b*, diaphragm *G*, and cap *K* containing the auxiliary valve *c*. Pull valve *C* out, clean its seat, and also make sure that its stem works freely up and down in hole *h*. Next, insert a screwed rod (supplied for the purpose) through the hole *h* into the tapped hole in piston *D* and see if the latter works freely. Note that *D* cannot be raised and lowered very suddenly, on account of the resistance of dashpot *E*. If piston *D* is found to be stuck fast, remove the dashpot *E*, pull out the piston and clean it carefully with fine emery cloth, wiping it quite clean before replacing. Having made sure that the auxiliary valve *c* has a good bearing on its seat, and also that its stem moves freely in its hole, replace cap *K* with valve *c* therein. Before putting on the spring case *I*, see that the diaphragm is clean and that there is no dirt between it and the spring case or the body *M*. If the reducing valve is disabled so that no steam will pass into the train pipe, remove dashpot *E*, as already described, and put a small block or nut under the piston *D* to hold it up and the valve *C* open so that steam can pass valve *C* and regulate the train-pipe pressure with the stop-valve, Fig. 2.

**5. Hose Couplers.**—The hose coupler is shown in Fig. 4; (*a*) shows a side view while (*b*) represents it as seen from above. In these views, *b* is the coupler body; *h*, the steam hose; *c*, the hose collar or band; *n*, the hose nipple; and *g*, the gasket, which, coming in contact with a similar gasket in the adjacent coupler on the next car, makes the coupler joint steam-tight.

This gasket *g* and its case *f* are shown separately at (*c*), the left-hand view representing the device as seen from the back,

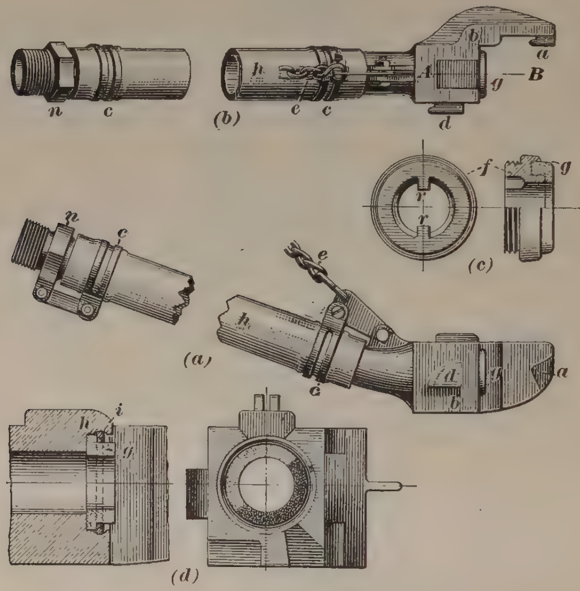



Fig. 4

and the right-hand illustration showing a side view of it, the upper half being in section, to show how *g*, the gasket proper, is held inside its case *f*. There are two ribs *r* inside the case *f*, their purpose being to assist in screwing the device in or out of place in the coupler body *B*; any flat bar of iron that will enter the case will answer for this operation.

The lipped projections, or lugs, *a*, *d* on the coupler body are for locking the pair of couplers together, *a* on the one

coupler engaging with $d$ on the other. The dotted lines in ($a$) show the outline of the inner surfaces of these lugs.

A modification of the straight-port coupler is shown in ($d$). The left-hand illustration represents the coupler cut in two to show the gasket in place; the other illustration shows the coupler as seen endwise. The end of the coupler is recessed out squarely at $h$ to take the gasket, while at $i$ it is cut under, forming a recess into which the split ring is sprung. This recess being formed slanting, so to speak, prevents the ring from coming out when sprung open in place, and it thus serves to keep the gasket in position when the coupler is not in use. This ring is very readily removed when required to withdraw the gasket.

A tail-coupler is sometimes used on the rear of the last car. By the use of this device all the train-pipe cocks may be left open and the condensed water allowed to flow into and drip from the rear coupler through an angle valve attached to the tail-coupler.

### CAR EQUIPMENT: DIRECT STEAM

**6. System 1.**—In dealing with the various car equipments, we will take the **direct-steam** system first. The arrangement of the piping varies somewhat on the various cars—ordinary passenger, parlor, baggage, express, mail, etc. Fig. 5 shows the arrangement of the piping on a passenger coach, together with the necessary valves, cocks, etc., ($a$) being a plan view of the car. In these views, which are all lettered to correspond with one another, $P$ is the train pipe, which, at mid-length of car, branches into the two cross-pipes $P'$, $P''$. These cross-pipes rise through the floor, underneath two of the seats, and receive the steam-inlet valves $v$, $v'$, by means of which the amount of steam allowed to enter the heating pipes in the car is controlled. $V$, $V'$ are the train-pipe cocks. Suppose that this car is the last one in the train, and that the end marked $R$ is the rear end, then the train-pipe cock $V'$ must be closed and all other cocks left open. If the other end of car, marked $F$, is the rear end, the cock marked $V$ will have to be shut, and the others left open.

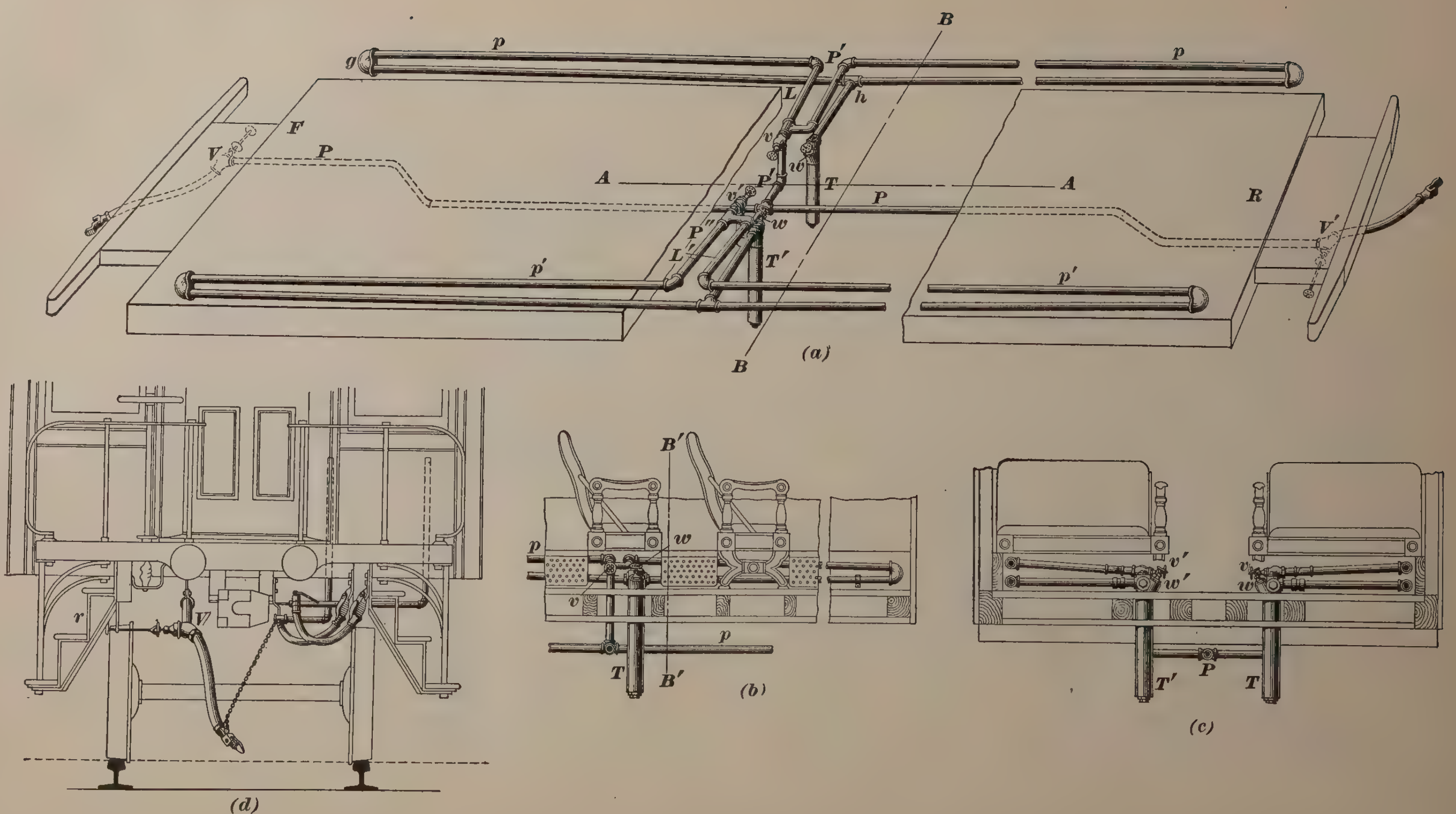



FIG. 5

Suppose again, that the ends of the car are as now marked—$F$ for front and $R$ for rear—and that it is not the rear car of the train; in that case, if we shut off steam to this car by closing cock $V$, we of course shut off steam from all cars behind it. If, however, we want to shut off steam from this car, but not from those behind it, we leave $V$ and $V'$ open and close valve $v$ or $v'$, according to which side of the car is required to be cut out.

After steam leaves valve $v$ it passes into the upper steam pipe $p$ and then to the end of the car, around the bend $g$, and returns along lower length of $p$ to the center of the car's length, at which point the two lengths of the lower pipe $p$ approach each other and turn into a **T** piece $h$ having a side outlet to which is fitted a drip or drain valve $w$ and a trap $T$.

The lengths of piping $p, p$ on one side of the car and $p', p'$ on the other constitute the heating surface, which, by radiating out its heat, warms the car, the amount of radiating surface being proportioned to the size of the car.

The train pipe $P$ is set so as to drain from the center to each end of the car. Also, the upper length of the heating pipe $p$ falls from the center of the car to each end, while the lower length falls from each end to the center, so that all condensation drains to the drip valve $w$ and trap. Views ($b$) and ($c$) are side elevations and ($d$) an end view of the car showing the arrangement of the piping, traps, and valves.

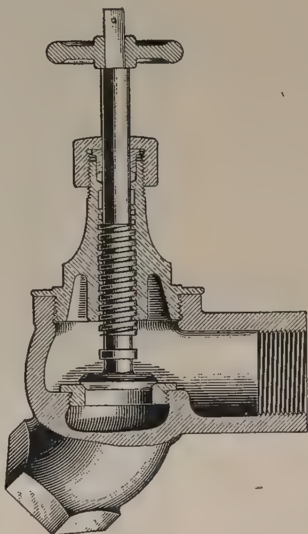


FIG. 6

At each end of the train pipe is placed a train-pipe cock, shown in Fig. 6 in section; its construction and operation can be clearly understood from the illustration. All the later equipment is provided with this type of end train-pipe cock.

**7.** The Safety Company uses two styles of automatic traps for discharging the water of condensation. Fig. 7 shows both these traps, (*a*) being used with straight steam; it can be set vertically, as its upper end is above the car floor. The other trap (*b*) is nearly horizontal and is used when the heating jackets are under the car, where the vertical trap would not be convenient.

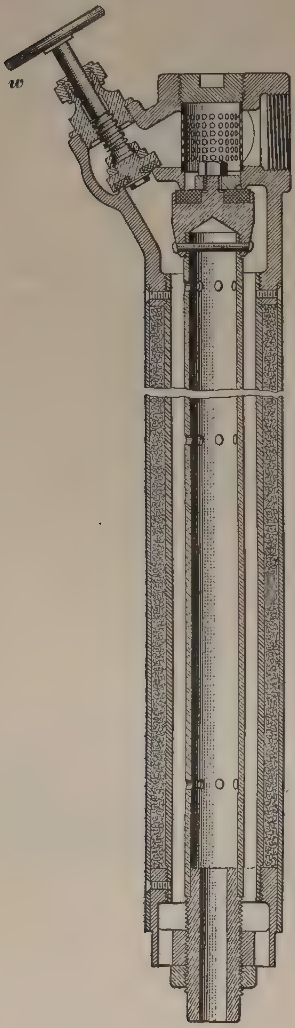



Fig. 7 (*a*)

These traps consist of a valve with a very long stem that is enclosed in an iron shell to which it is fastened at one end while it has a valve at the other. Its operation depends on the difference in expansion between the stem, which is a brass pipe, and the iron shell enclosing it. After the condensed water has passed out and the brass pipe is in contact with the hot steam flowing into the trap, it expands more than the cast-iron shell and thus pushes the valve against its seat, shutting off the flow of steam. As it cools, the brass contracts more than the iron until the valve is open just enough to allow water to pass it. It is adjusted by a screw and locknut.

When steam has been turned on the car for testing, adjust the trap by loosening the locknut on the end, open the trap by screwing out the seat (which is controlled by the small square stem) until steam escapes freely, and then closing it until a point is reached where hot water but no steam escapes.

**8.** First of all see that all the steam hose are coupled up, and then open wide all the train-pipe cocks. Turn on steam and blow out all the condensation from the train pipe. Then shut the rear cock on the train, to prevent further escape of steam.

Regulate the heat by means of the valves $v$, $v'$, Fig. 5 ($a$). The temperature of steam increases with the pressure; the higher the pressure, therefore, in the radiating pipes, the higher will be the temperature. The volume and pressure of steam admitted to the pipes are controlled by the valves $v$, $v'$ under the seats. The wider the valve $v$ or $v'$ is opened, the greater is the volume of steam admitted to the pipe $p$ or $p'$ on that side of the car. This inlet valve and the blow-off valves on the trap are close together. The inlet valve is the

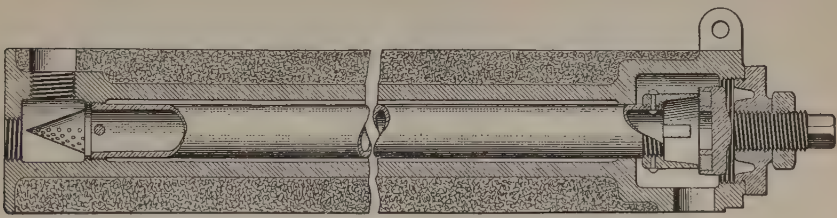


FIG. 7 ($b$)

larger of the two; it is also distinguishable from the other by having the words "inlet valve" on its wheel handle.

The traps must be adjusted so that hot water, but not steam, escapes through them. When the train is about to be laid up, the rear train-pipe cock ought to be opened before cutting off the engine, so that all condensation will be blown out of the pipes; it is desirable to open this cock before reaching the last station of the run. All valves must be left wide open and all the hose uncoupled.

At the beginning of the cold season, it is a good plan to clean out the pipes well. This may be done by flushing them with water, or by blowing steam through them under considerable pressure, at the same time tapping the pipes to remove any scale therein. While the pipes are being blown out, the drip valves $w$ should be left wide open.

**9. Regulating System.**—One of the drawbacks to using the direct steam system is the liability to overheat the car; the heat of the radiating pipes being then much greater than when hot water is used. This being so, it would be an advantage to be able to vary and control the total heat given out by the pipes. As ordinarily done, this is not very satisfactory, for the usual procedure is to throttle the steam and reduce the pressure. But the degree of regulation obtained in this manner is not considerable, for the range of temperature corresponding to the reduction of pressure that is practicable is not great compared to the whole temperature. Obviously, a desirable arrangement would be one wherein we could decrease the actual amount of heating surface used, and to decrease it by appreciable amounts. As will be seen in Fig. 8, it is possible to cut out one-quarter, one-half, or three-quarters, or the whole of the heating surface that warms the car.

In this system, as also in that illustrated in Fig. 5, the radiating pipes that constitute the heating surface consist of pipes on each side of the car, placed vertically one above the other; but in this case they are actually separate pipes, whereas in Fig. 5 the pipes are one continuous length bent round at the two ends so that the upper and lower lengths of piping form one continuous pipe. In the present case, however, steam can be in either the upper or the lower length without being in the other, for each length is closed at its far end with a cap $g$ or $g'$, and so is rendered separate from its neighbor. Another point of difference is that the steam comes in at the end of the car, instead of at the middle, as in Fig. 7.

Referring to Fig. 8, $P$ is the train pipe, in which are the two train-pipe cocks $V$, $V'$ that serve to shut off the steam from the cars in the rear of the one under consideration. Between these cocks is the small piece $a$ from whence branch the cross-pipes $P'$, $P''$ leading one to each side of the car. In Fig. 5, the steam supply to the car is controlled by the angle valves $v$, $v'$; in the present case, this duty is performed by the distributing or regulating cocks $v$, $v$ situated at one end of the

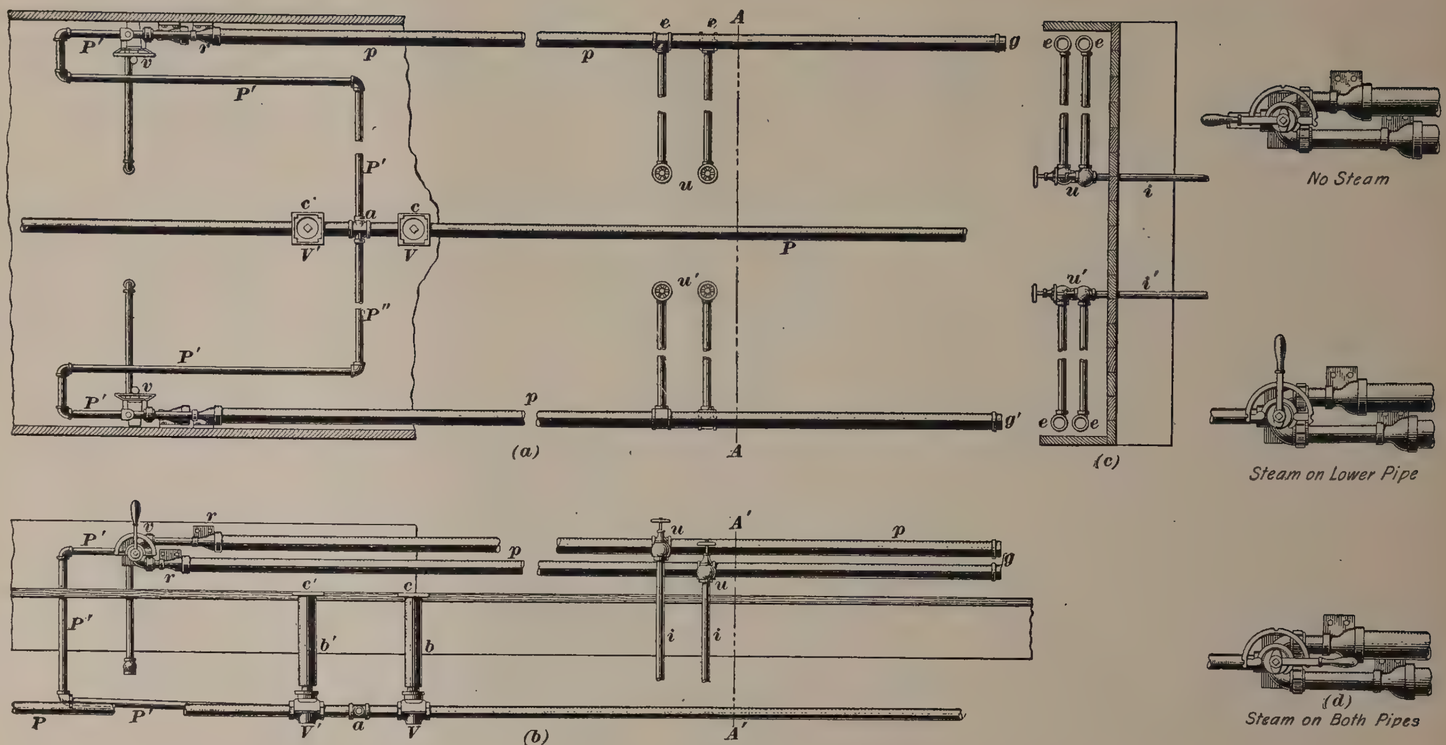


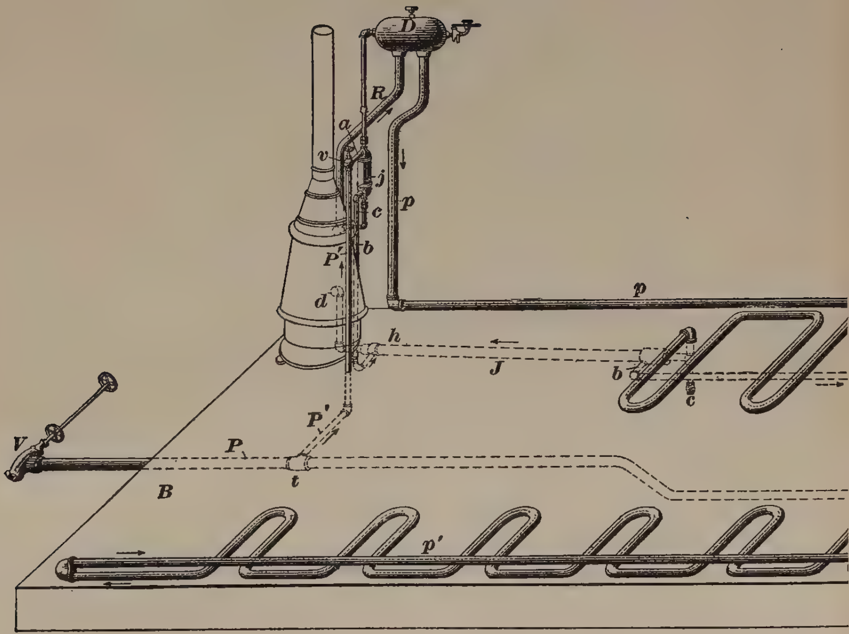

FIG. 8

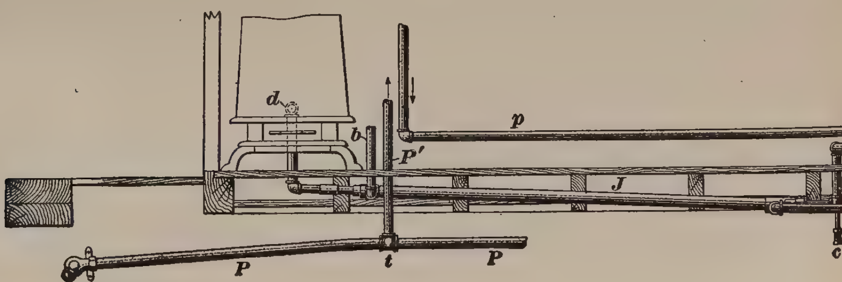
car. From this cock $v$ run the radiating pipes $p$ along the side of the car near the truss plank, as before. These pipes have a slight fall from the regulating cock $v$ to near the far end $g$ of the car. In each of these pipes, at about 4 feet from the end, is placed an eccentric **T** piece $e$, which is located underneath a seat when practicable, and a 1-inch pipe leads from it to the drain valve $u$, from which runs the drip pipe $i$ through the floor of the car. Where there are no cross-seats, these drain valves $u, u'$ are placed near the side of the car. Each of the radiating pipes is set with a fall from the regulating-cock end to the eccentric **T** piece $e$; it also has a fall backwards from its end $g$ to this same **T**. Thus, these pipes run downwards toward the valve $u$ from either end of the car.

Fig. 8 ($d$) shows the regulating cock in three positions; the views are taken looking sidewise at the apparatus when in position in the car; in fact, they correspond to view ($b$). The upper illustration of ($d$) shows the position of the cock handle when steam is shut off from both pipes, the middle one represents steam being admitted to the lower pipe only, while the bottom illustration shows steam going into both pipes.

This system is very convenient for cars running in suburban service, where the cars must be heated up quickly for short runs. This can be readily done by heating all the pipes, and by a movement of the cock handle, which is a permanent fixture, the heating power can be reduced one-half—the reduction being uniform throughout the car, owing to the pipe that has been cut out extending the whole length and not occupying merely one particular section. So, also, whether one pipe or three pipes are cut out, there is still a practically uniform heating of the car, excepting such slight differences as may result from there being an excess of heating surface on one side.

**10.** See that all the steam hose are coupled up, and then open wide all the train-pipe cocks. Turn on the steam and blow all condensation from the train pipes. Then shut the rear train-pipe cock, to prevent further escape of steam. The heat is regulated by means of the valves in the radiating


D
R
a
v
j
c
p
b
P'
d
p
h
J
b
c
V
P
P'
t
B
p'


d
b
p
P'
J
P
t
P
c

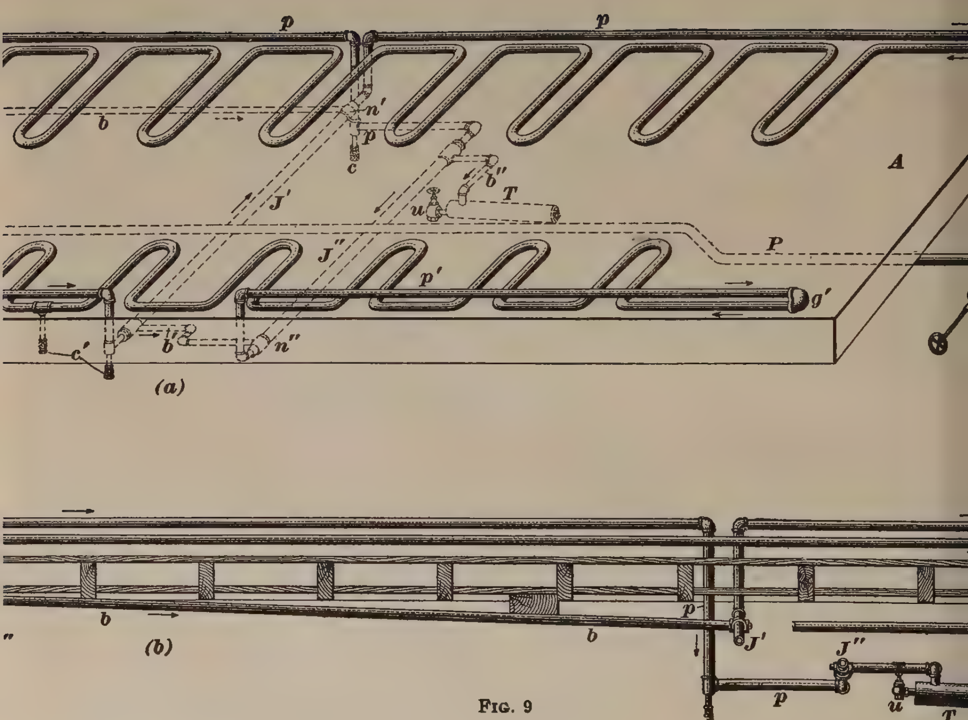
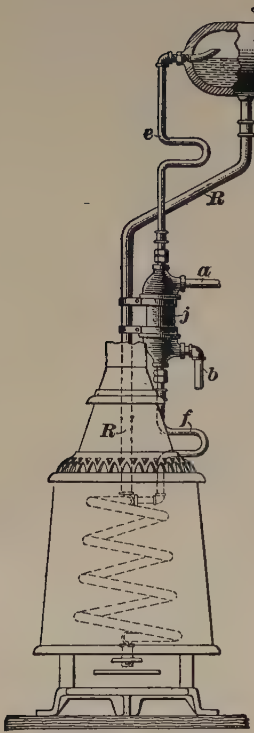
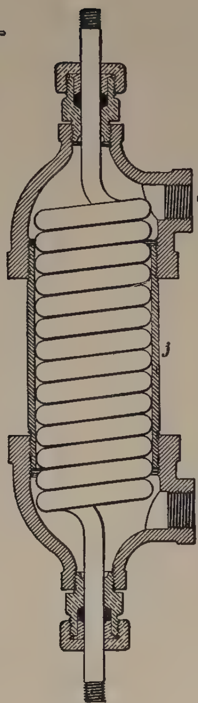


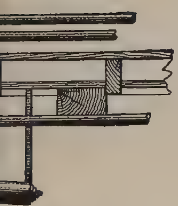

FIG. 9

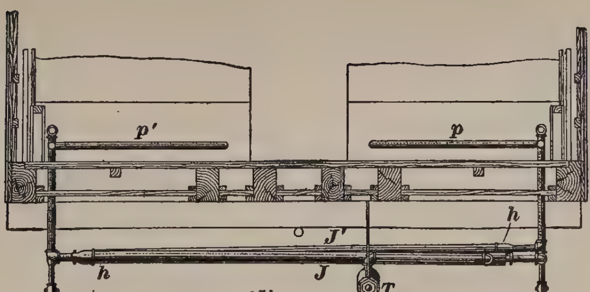


(c)



(e)





(d)

pipes. The valves are adjusted, as explained, to permit sufficient radiating surface being brought into play to give the required temperature.

The drainage of the radiating pipes is effected by means of the drip valves $u, u'$ placed near the ends of the car. When steam is turned on, the drip valves on the lower pipes should be opened until steam escapes from them; the valves on the upper pipes need not be opened except in very cold weather. After steam escapes from the drip valves, they are to be closed.

## CAR EQUIPMENT: HOT WATER

**11. Single Circulation: Single Train Pipe.**—In this system, shown in Fig. 9, the fire in the Baker heater is dispensed with, its place as the heating agent being taken by steam drawn from the boiler of the locomotive, the heater being left in such a condition that at any time fire may be substituted for steam from the locomotive. Steam is taken from the train pipe $P$ at the **T** piece $t$, and goes through the pipe $P'$ to the regulating valve $v$, whence it passes through $a$ to the antihammering jacket $j$, located at the heater as shown in view ($c$). A sectional view is shown in ($e$). It leaves this jacket by the pipe $b$ and enters the high end $h$ of the heating jacket $J$, passing out again at the lower end $b$ and running along to the high end $n'$ of the cross-over jacket $J'$, which it leaves by the pipe $b'$ and enters the high end $n''$ of the cross-over jacket $J''$. It leaves the lower end of this third jacket by the pipe $b''$ and passes into the high end of the trap $T$. The action of this trap has been described; it is fitted with a blow-off valve $u$, as before. All these heating jackets have an upward inclination in the direction of the circulation of the heated water, the steam thus flowing down them, so to speak, having a gradual fall from the time of entering the high end of jacket $J$ until leaving the lower end of jacket $J''$. The water inside these jackets is heated by the steam passing through them, which tends to induce a complete circulation of hot water throughout the system. This practice of applying the heat at several points in the system is of considerable

benefit. The heat of the steam is, of course, not as great as would be that of fire in the heater, but whereas, the latter is applied to only one portion of the circulating system, namely, the coil in the heater, the former is applied to three separate portions, the result being a more uniform heating and a higher average temperature in the pipes throughout the car.

These three jackets in each case hold the steam that heats the water. The ordinary Baker coil is connected at both ends with the circulating system, so as to be used with fire when required. Wherever the heating jackets or the steam pipes extend through the car floor, they are clothed with a suitable non-conducting covering. Arrows placed alongside the pipes $b$, $b'$, and $b''$ show the path of the steam, that of the hot water being indicated by arrows placed on the pipes $p$, $p'$ and on the heating jackets $J$, $J'$, $J''$. The temperature of the car is readily regulated by controlling the supply of steam from the train pipe, this being done by means of the angle valve $v$.

End train-pipe valves, Fig. 6, are used with this system in place of the older type of train-pipe valves near the center of the car shown at $V$ and $V'$, Fig. 8.

**12.** The **heating jackets** are shown in Fig. 10. The water of circulation flows through the inner pipes $C$, which are of copper $1\frac{1}{4}$ inches inside diameter. The live steam enters from the train pipe at the end fittings $D$ into the annular space between the copper pipe and the 2-inch iron pipe surrounding the pipe containing the water. Thus the water passing through the copper pipe takes up the heat from the live steam. At the end $D$, the copper pipe is screwed into the fitting and the iron pipe or jacket is also screwed into the same fitting. On the other end of the jacket, provision is made for the difference in the expansion of the copper and iron pipes. The 2-inch iron pipe is screwed into the fitting in the usual manner, but the copper pipe passes through a packed gland that allows the copper pipes to expand and contract without breaking any joints. The trap is attached to the opposite end of the jacket from the steam inlet. These jackets are single for a single circulation and double

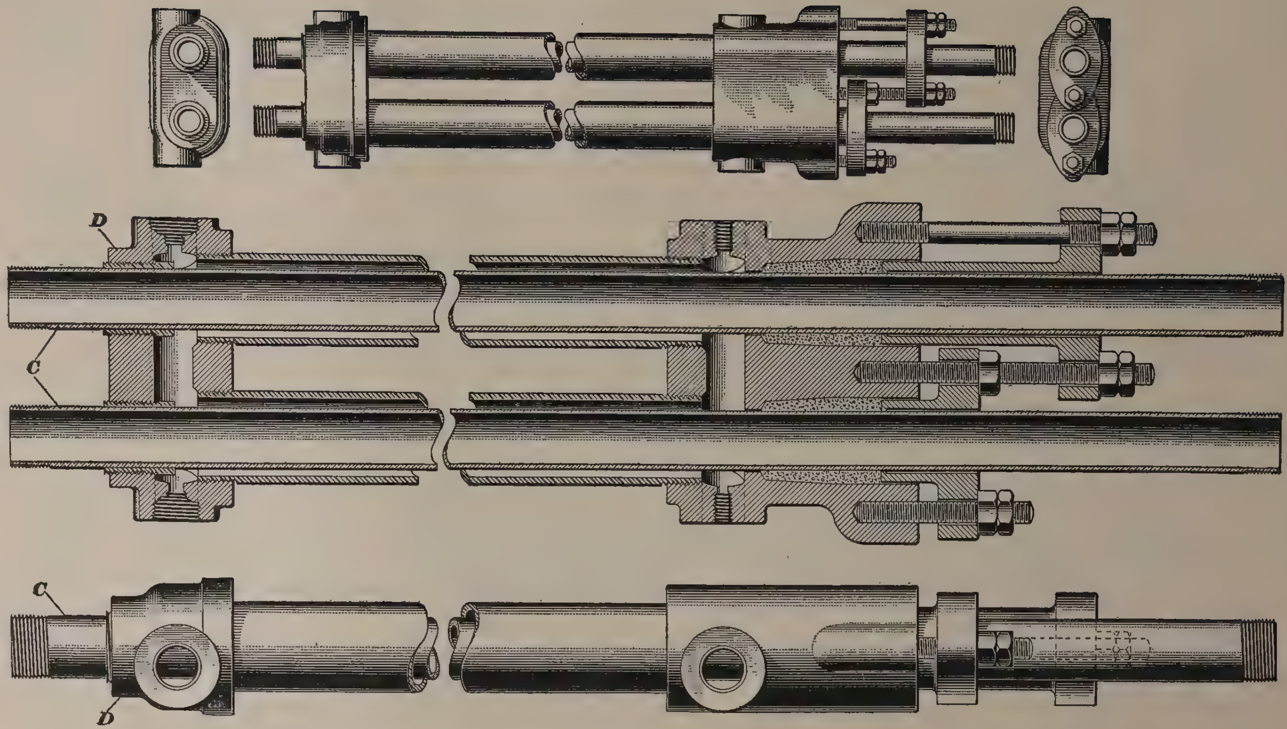



FIG. 10

for a double one. There are two of them under the car attached to the circulating pipes at suitable distances apart so that each jacket will heat its share of the piping. In addition, there is an antihammering jacket *j*, shown in Fig. 9 (*a*) and (*c*), in the car attached to the riser into the expansion tank, which also heats the water.

This jacket is shown in section in Fig. 9 (*e*). It is placed in the riser between the Baker heater and the expansion drum. Steam enters at the top through valve *a*, passes around the outside of the copper coil, heating the water inside this coil, which first rises to the expansion drum and then passes around the circulation. The steam passes out at the bottom of this jacket to the other jackets under the car and the condensed water from all the jackets passes to the trap *T* and is discharged.

**13.** The series of hot-water pipes is arranged as follows: From the top of the pipe coil in the stove heater runs the hot-water riser *R* into the drum *D*. The heated water passes out of this drum through the pipe *p* and runs along the side of the car as far as the center, where it drops below the floor and runs into the jacket $J''$, passing therein to the other side, where it rises into the car again and goes through pipe $p'$, which runs along the side of the car to the end *A*. At this point, it makes the turn $g'$ and comes back along the floor, in a series of loops under the seats, to the other end *B*, where it again turns and comes back to the center of the car by the upper straight length of piping $p'$. Here it again drops below the floor and passes to the other side of the car through the cross-over jacket $J'$; it then rises and goes through the straight upper length of piping *p* to the end *g* and returns by the looped pipe to the heater end of the car, where it drops below the floor and enters the jacket *J*, passing out of that into the bottom part of the heater coil in the stove at *d*. This system is a "closed" one, as were also the systems previously described, the same body of water circulating through the pipes over and over again. Hence, when it has once been filled with water to the proper level,

no further attention is required. Draw-off cocks $c, c'$ are placed in the location shown.

The supply of steam is drawn from the train pipe $P$ at the fitting $t$, this being made the highest point in the pipe, so that water may drain from there down to each end of the car. End train-pipe valves are used with this system.

The purpose of the small jacket $j$, Fig. 9 ($c$), placed above the heater is to prevent water hammer, as the knocking noise in the pipe of a heating system is called, this being prevented by producing a pressure in the expansion drum as soon as steam is turned on; the antihammering jacket heats and expands the water, the pressure thus produced being proportionate to the heating of the water in the jacket. The bends in the pipe leading to and from the jacket $j$ at $e$ and $f$ are intended to prevent breaking the joints when the steam is first turned on and the water circulates in the jacket before it does in the riser $R$. The discharge into the drum $D$ comes out above the level of the water in the drum; this also aids the circulation.

In order to discharge the condensation from the steam pipes, and at the same time prevent the escape of uncondensed steam, the automatic steam trap shown in Fig. 7 ($b$) is used. It is not thought necessary to run an extension handle through the floor to the valve $u$, the object of this valve being merely to afford a means of blowing out the steam pipe occasionally or of getting rid of the condensation, if from any cause the trap should fail to work.

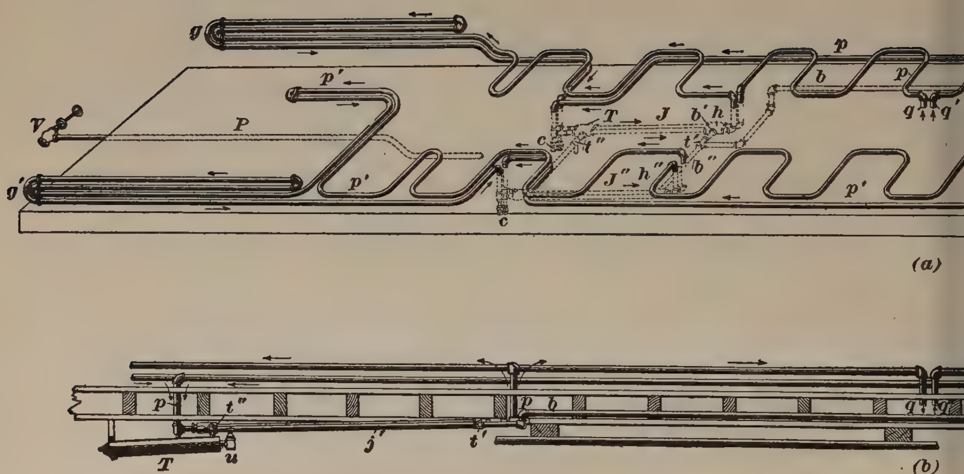
The Baker heater is used with this system, and is put up and kept in such shape as to be ready for use in the ordinary way (by fire) when emergency arises. After being put in place, the seal of the Baker heater pipes remains unbroken, and a fire may be started in the heater whether steam is in use or not, and without having to adjust any cocks, valves, or traps. The water always circulates in the same direction, whether fire and steam are used separately or together.

**14.** Couple up all the steam hose and open wide all the train-pipe valves or cocks. Turn steam on the system and let it blow through the train pipe until it comes out at the

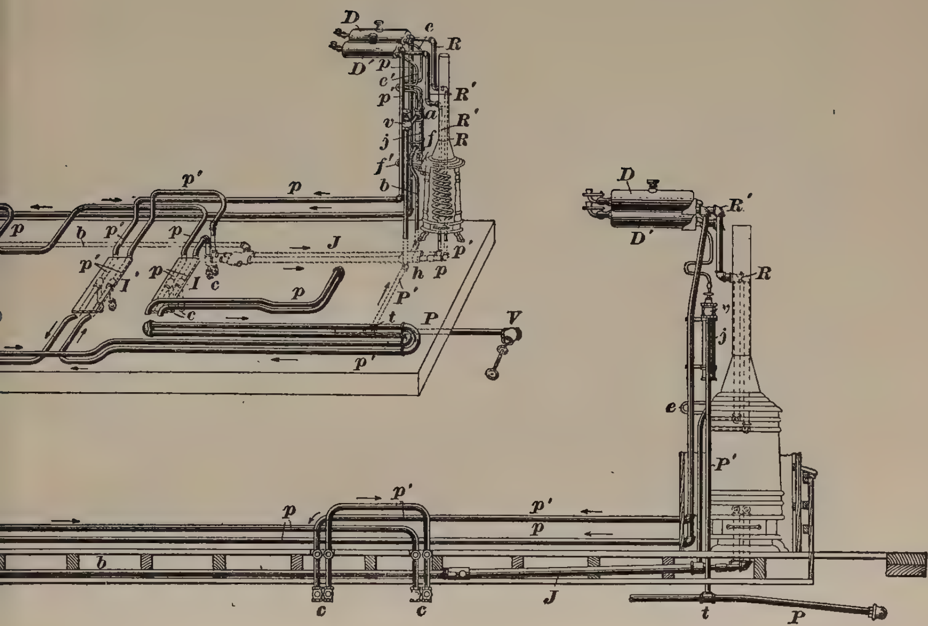
rear end of the last car; then close the rear valve $V$ to prevent steam escaping. Next open wide the valve $v$ and adjust the trap $T$, so that practically only water escapes therefrom. When the car is warmed up sufficiently, regulate the heat by means of the valve $v$.

When the engine is to be disconnected from the train at the terminal, open wide the valve $V$, or the rear train cock, before reaching that station. Leave all valves wide open, the hose uncoupled, and a fire started in the heater. It is not necessary to clean out the piping if the system has been kept full of water all summer. If a hot-water system fails to circulate properly, and it is found that the water level is correct, a test may be made to ascertain whether or not the system is stopped at some point. To do this, draw off the water, connect live steam to one of the draw-off cocks, and then blow steam through the pipes, opening all draw-off cocks and the filler cock and noting whether steam comes out of them. As fast as each successive cock is found to blow steam, close it and pass on to the next one, proceeding thus until every foot of the circulating pipes has become hot, which will be proof that there is no stoppage in the pipes. After it is certain that the pipes are clean refill the circulation and the heating system is ready for service again.

**15. Double Circulation: Single Train Pipe.**—In Fig. 11 is illustrated a heating system that is especially suitable for sleeping and private cars and also for parlor, dining, café, and large postal cars. It is a **double-circulation system,** there being a separate set of heating jackets, expansion drums, and piping on each side of the car. Inside the Baker heater there is a double-coil generator, one of whose coils connects with the riser $R$, drum $D$, and piping $p$, and the other with $R'$, $D'$, and $p'$; thus, each side of the car has its own circulation. Each set of piping is heated in three places by jackets, the jacket $J$ serving for both sets $p$, $p'$, while jacket $J'$ is exclusively for piping $p$, and $J''$ for piping $p'$. These jackets are so located as will aid most in the circulation, dividing the system into three parts, as already mentioned.



F




§ 27

13181

As seen from the illustration, end train-pipe valves are here used, steam being taken from the train pipe at the connection $t$, whence it passes through pipe $P'$ and valve $v$ to the antihammering jacket $j$. From this jacket, two pipes $e$, $e'$ lead to the two drums $D$, $D'$, and two pipes $f$, $f'$ lead to the coils inside the Baker heater. From the lower end of the drum $j$ runs the pipe $b$ carrying steam to the three heating jackets. After leaving the first jacket $J$, the pipe $b$ runs toward the center of the car, branching off at the **T** fitting $t'$ into the pipes $b'$, $b''$ that lead to the jackets $J'$, $J''$. It leaves the other end of the trap by the pipes shown, and by means of another **T** fitting $t''$ goes to the trap $T$.

The course of the radiating pipes may be readily traced in the illustration by aid of the arrows and letters marked thereon. The piping $p$, on its return to the heater, dips down under the floor at $q$ into the jacket or box around the water tank, whence it rises again through $q'$ and proceeds as shown. (The water tank here mentioned is that used for storing water on parlor and sleeping cars.) The heater pipes are run through the floor and around the inside of the box that encloses this tank, so as to prevent the water from freezing in cold weather. Thus, the length of piping $p$ is not broken at this point, but is continuous from $q$ to $q'$; the pipes are shown broken here merely for convenience.

Each system of piping $p, p'$ is provided with three draw-off cocks $c$, as shown. Some of these cocks are placed under the low ends of the three heating jackets; the others are placed at the heater end of the car, where the piping crosses over; in doing this, the pipes dip down under the floor and form a vertical loop that has to be drained. An iron plate $I$ or $I'$ is fitted over the part of the floor where the pipes pass under.

## THE CONSOLIDATED COMPANY'S SYSTEM

**16.** The general scheme of conveying and utilizing steam from the engine in the Consolidated Company's system is virtually the same as in the other systems. In one of those about to be described, the steam mixes directly with the circulating water; in others, steam jackets and a closed circulation are used.

### ENGINE EQUIPMENT

**17.** Fig. 12 shows the arrangement of the engine equipment, (*a*) being a side view and (*b*) an end view of the engine. Steam is taken from the boiler at the stop-valve *V*, passing thence by pipe *p* to pressure regulator *R*, which reduces its pressure to that required in the train. From *R*, steam passes through pipe *P* to the couplers between engine and tender, and thence along pipe *P'* to the train. The fitting *t* allows the steam to pass to the pressure gauge *G* and relief valve *v*. The couplers *c* between the engine and tender are the Sewall lever couplers; the coupler *c'* at the rear end of the tender is a standard Sewall coupler.

**18. Stop-Valve and Pressure Regulator.**—The stop-valve used is an ordinary globe valve. Its construction permits it to be connected directly to the boiler, as in Fig. 12, or else placed horizontally at the side of the boiler; or it can be located in any suitable position in the steam pipe.

The pressure regulator is the same as shown in Fig. 3, namely, the Mason regulator.

**19. Relief Valve.**—The relief valve *v* is shown in section in Fig. 13. It is used for the purpose of relieving the train pipe and also to warn the engineer if the pressure in the train becomes greater than intended. It is usually set at 50 pounds.

In the figure, *a* is the valve disk held down on its seat *b* by the spring *c*, the force of which is regulated by the set-screw *d*. The ring *e* screws up and down on *a*. The steam comes in through *A*, and passes between the arms *f* of the

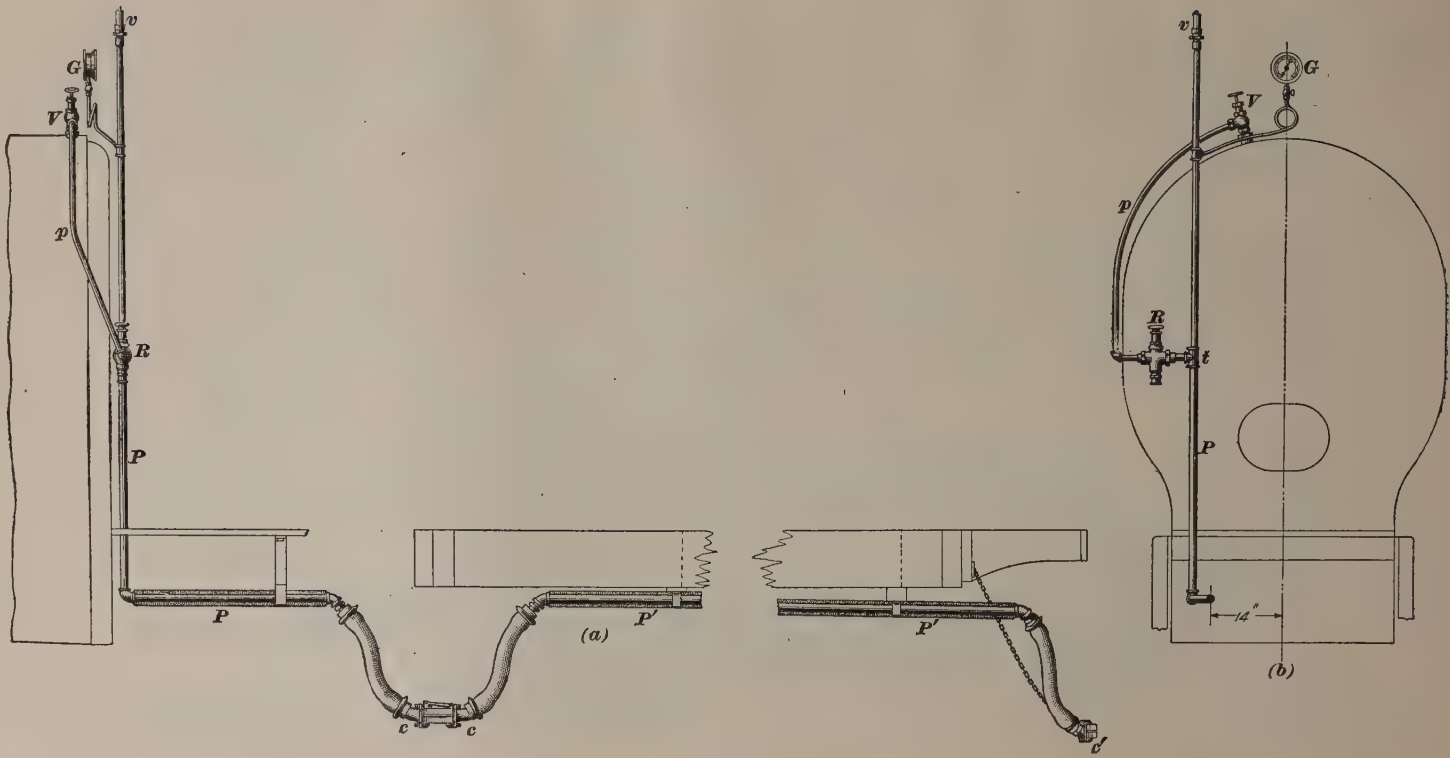



FIG. 12

base and lifts the valve *a*; two openings, between *a* and *b* and *e* and *b′*, through which the steam must pass, then present themselves. After steam has raised the valve *a*, it still encounters the last-named passage and is thus held back, as it were. The wider this passage, the more easily will steam blow off; the opening it presents can be increased or decreased by screwing the ring *e* up or down, locking it in its new position by means of a setscrew.

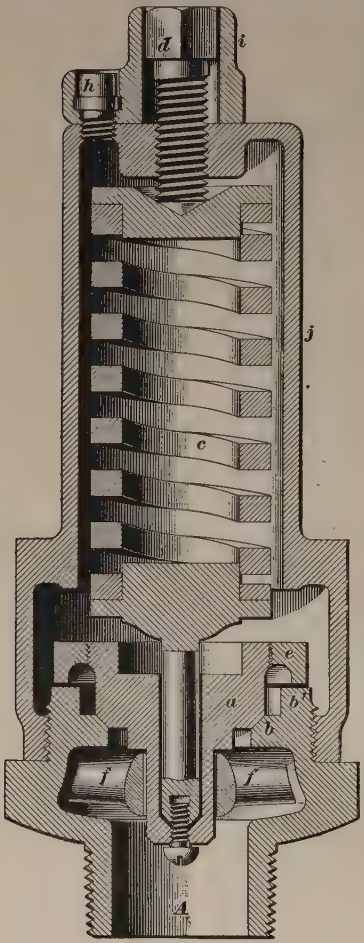



FIG. 13

If the valve pops too suddenly and reduces the pressure too much, screw *e* farther up on *a*, so as to increase the opening between *e* and *b′*. If it does not pop promptly, opening and closing too gradually, screw *e* down so as to approach nearer *b′*. It will be found, as a rule, that when the setscrew *d* is changed, the position of the ring *e* must be readjusted.

To increase the pressure at which the valve pops, screw down *d*; to lessen it, screw it up.

To take the valve apart, unscrew the lock-screw *h*, remove the shield *i*, and relieve the compression of the spring by slacking back the setscrew *d*; then unscrew the casing off the base.

Before putting the valve in place, blow out the pipe to which it connects, and use very little lead or grease in

connecting it up, as it may get in the valve and impair its sensitiveness.

**20. Operating the Engine Equipment.**—When the train is first made up, the engineer will, on receiving the signal for steam, slightly open the pressure regulator *R*, and then open wide the stop-valve *V* until *R* is receiving full boiler pressure. Next open *R* until gauge *G* shows the required pressure—25 to 50 pounds, according to the weather and the length of the train.

In shutting off steam, close valve *V*, but do not alter the regulator *R*; then, when next delivering steam to the train, only *V* has to be opened. The regulator *R* is to be altered only when steam is in the pipe and for the purpose of adjusting the pressure in the train; it is not to be used for admitting and shutting off steam to the train, this being done solely by the stop-valve *V*. This valve *V* should be closed about 3 minutes before entering stations that are terminal points or at which it is intended to cut off the engine or take on additional cars. Steam should not be shut off from the train while on the road without giving the trainmen notice.

**21. Hose Couplers.**—The steam coupler used by the Consolidated Company is that known as the Sewall coupler. It is shown in Fig. 14, view (*a*) showing the parts uncoupled, view (*b*) showing it coupled up, and view (*c*) showing a sectional view of it. *b* is the body and *c* is the collar holding the hose *h* in place on the nipple *j*. The two curved lugs *a* and *d* serve to lock the coupler together, forcing the gaskets *g* into contact with each other. On the inner face of each coupler are formed a lug, or tooth, *e* and a space *f*, the tooth in the one coupler engaging with the space in the other. These teeth act as a guide when coupling, and also subsequently keep the couplers in their right position relative to each other. The gasket *g* is gripped between the body *b* and the end *h* of nipple *j*, being tightened by bolts *i* tapped into the body. If the gasket becomes at all worn, it can be forced outwards without removing it, by tightening the nuts of bolts *i*. *k* is an air space surrounding the part of the

nipple that would otherwise expose bare metal to the atmosphere; this prevents a great deal of the condensation that

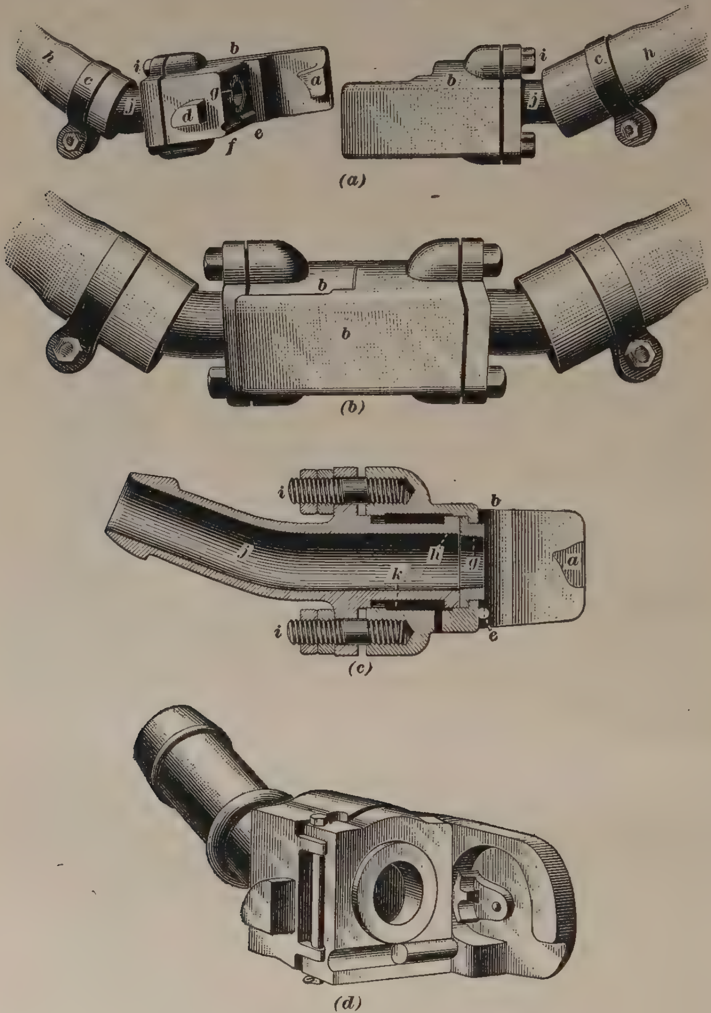



Fig. 14

would otherwise take place. This coupler will couple with any straight-port coupler, and uncouples automatically. It presents a practically straight path to the steam.

The coupler used between engine and tender is the same as here shown, with the addition of a lever shown in Fig. 12. This coupler, when connected with the adjacent one, can be locked in position by means of the lever, when they will not uncouple until this lever is put back. It will couple with the ordinary coupler, the locking device not being brought into use unless desired. Another form of Sewall coupler, in which the gasket can be taken from the coupler head and replaced with a new one much easier than with the older pattern, is shown in Fig. 14 (*d*).

---

### CAR EQUIPMENT: DIRECT STEAM

**22. General Description.**—Fig. 15, view (*a*), shows the method of piping used in the direct system of heating installed by the Consolidated Company. Steam in the train pipe $P$ is controlled by end train-pipe valves $V$ similar to the ones shown in Fig. 6. A straight-port train-pipe valve, shown in Fig. 15 (*b*) and (*c*), is now used. This valve is opened and shut by an extension handle and stem. There is a small groove in the seat that allows condensation to pass off and prevent freezing at the rear cock. From $P$, the steam passes to the sides of the car by the double cross-piece $c$, called the main steam casting, proceeding by pipe $P'$ to the regulating, or controlling, valve $v$, whence it goes through pipe $d$ to the piping $p$ that runs along the side of the car. After traversing the length of the car, the steam returns to the loop $L$ and passes through the drain valve $u$, and thence through pipe $i$ to the casting $c$, and out of the drip pipe $j$ to the trap, when such is used.

Another arrangement of piping is also used in which there are three pipes on each side of the car instead of two. The ordinary **T** piece $e$ is replaced by a double center **T** connecting the two upper pipes, so that live steam passes from pipe $d$ into the other pipes. The return bend $g$ is replaced by a three-pipe manifold, by which the steam that has come through the two upper pipes $p$ may return through the lower pipes $p$ to the center of the car, where a special return **T** replaces the loop $L$, a pipe leading to valve $u$ as before.

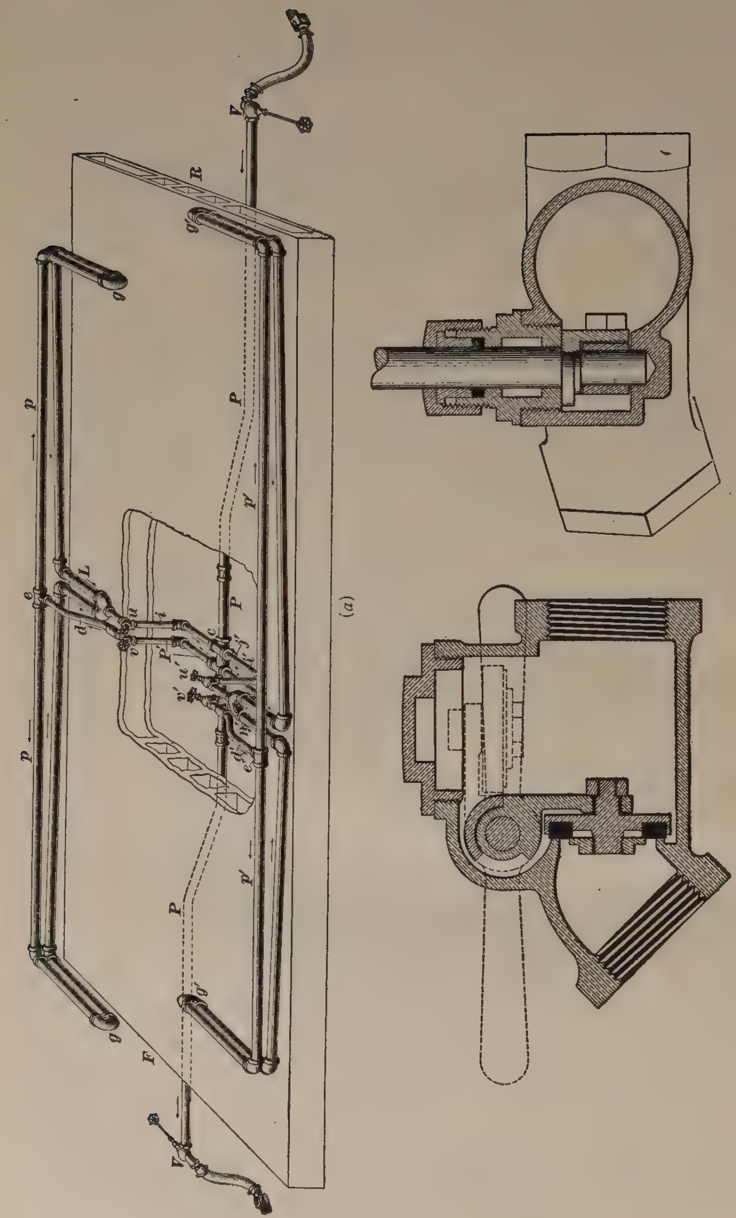



FIG. 15

The regulating valve $v$ and the drain valve $u$ are identical, except that the former has the larger wheel. The train-pipe

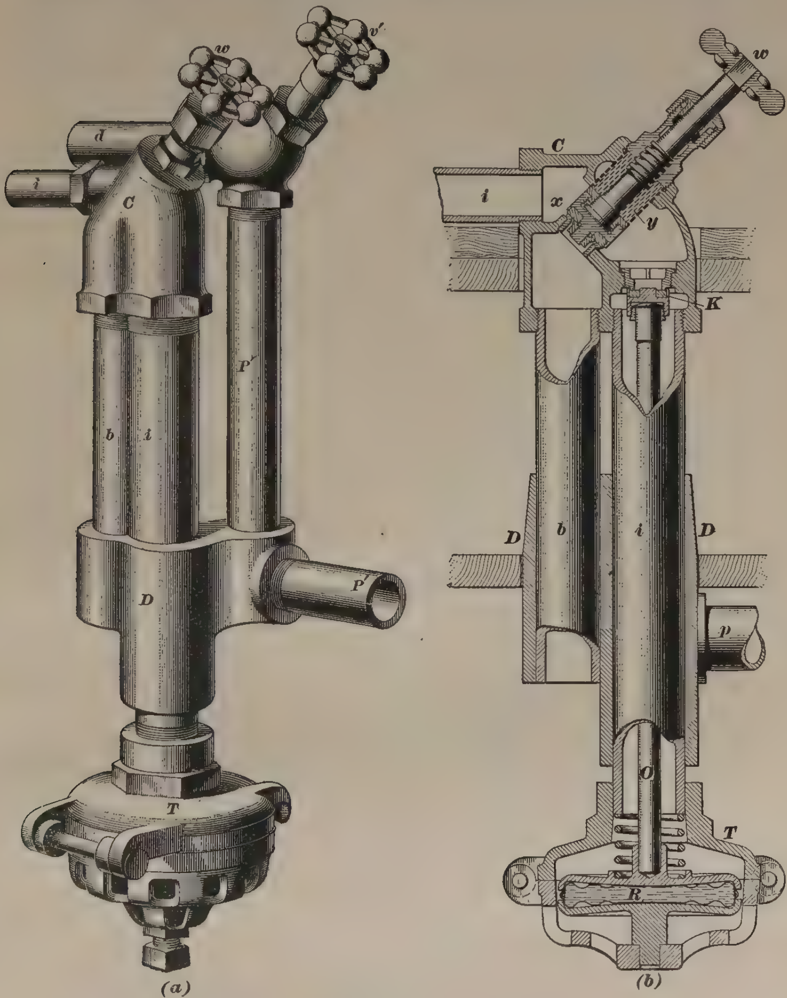



FIG. 16

valve $V$ has an extension handle, accessible from the side of the car. In very cold climates, a notch is cut in the seat of this valve, or a small hole is drilled in it, so that there will

be a constant slight discharge of steam and condensed water, preventing any freezing of the train pipe.

The casting $C$ plays an important part, as it keeps the water of condensation from freezing in pipe $j$. The live steam from the engine passes through this casting in close proximity to the drip pipe $j$; therefore, as long as there is steam in the train pipe, the drip cannot freeze.

Sometimes it is felt advisable to use a thermostatic trap to look after the condensation, instead of having the drip valve $u$. When such is the case, the apparatus shown in Fig. 16 is used. It consists of the diaphragm $R$ operating the valve stem $O$, opening and closing the valve $K$. When steam passes valve $K$ and through pipe $i$ it strikes diaphragm $R$ and heats it so that it expands and closes valve $K$, preventing the steam from coming out of the radiating pipes. When no steam is passing valve $K$, the diaphragm $R$ contracts and opens $K$, thus allowing the condensation to pass out as it accumulates in the radiating pipes. View ($a$) shows a perspective of trap and steam pipe, while view ($b$) gives a sectional view of trap and blow off. When the automatic valve is open, the condensation comes in through pipe $i$ and passes down to the thermostatic cell inside the casing $T$, whence it escapes. With a view to keeping the drip from freezing, a hot metallic connection $D$ is used; pipes $b$ and $i$ pass through $D$, while a passage inside connects the two lengths of $P'$. Thus, the steam in pipes $P'$ keeps the casting, and therefore the drip pipe, always hot; $w$ is a blow-off valve; its casting $C$ is provided with a sediment pocket $x$ in which any scale and dirt that may come through the pipes is collected, instead of passing down into $T$, as screen $y$ stops it. By opening this valve the accumulated deposit may be blown through pipe $b$ and discharged underneath the car.

While the contact of the hot metal $D$ keeps the casing $T$ warm, the latter never approaches the temperature (about 170° F.) at which the diaphragm would actuate the valve inside the trap. The supply of steam to the car is controlled by valve $v'$, so that there is always steam in $P'$ to keep the drip pipe warm, even when steam is shut off that particular

car. This warming of the casing $T$ will permit of the trap being placed far enough below the bottom of the car to keep the discharge clear of the sheathing and yet be in no danger of freezing. The steam valve $v'$ has a projection on its seat with triangular notches cut in it, by which the supply of steam to the radiating pipes can be more closely regulated than with an ordinary globe valve. This valve is shown in Fig. 17.

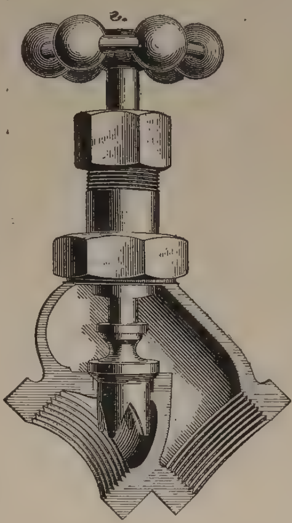


FIG. 17

**23. Operating the System.** First couple up all the steam hose, and make sure that all train-pipe valves $V$ and drain valves $u$, $u'$ are wide open, and that all steam valves $v$, $v'$ are shut. Let steam blow through the train pipe until dry steam comes out at the rear end of the train; then close the rear train-pipe valve. Next open all the steam valves, commencing with the rear car; open them not more than $1\frac{1}{2}$ turns. When the pipes are all hot, if the drainage of condensed water is regulated by hand, leave the drain valves open about $\frac{3}{4}$ turn and shut down the steam valves to within about $1\frac{1}{4}$ turns of being closed. Each side of the car is independent of the other, and the piping on one or both may be brought into use as desired. The steam and drain valves are under the seats near the center of the car; the valve with the large wheel is the steam valve, the drain valve having a smaller wheel.

Regulate the heat by the steam valves; about $\frac{3}{4}$ turn gives a full opening. In very mild weather, the drain valves should be entirely closed, thus retaining all condensation; the temperature can then be regulated by these drain valves, opening them for a few seconds between stations when more heat is needed. In doing this, some of the condensation escapes, making room for live steam. If the cars are provided with

traps, Fig. 16, the hand-operated drain valves *u* are not used, and the blow-off valve *w* can be kept closed.

The rear train-pipe valve can be left open just enough to permit hot water, but not steam, to pass out and thus keep the pipes clear of condensation. In frosty weather, the valve, if it has no leakage groove in its seat, must be left open enough to prevent the rear end of the train pipe freezing.

When cars are to be left without steam, all valves must be left open and all hose uncoupled. When approaching a station where engines are to be changed, close all valves inside the car and open the rear train-pipe valve. Blow through for about 3 minutes and then get the engineman to shut off steam.

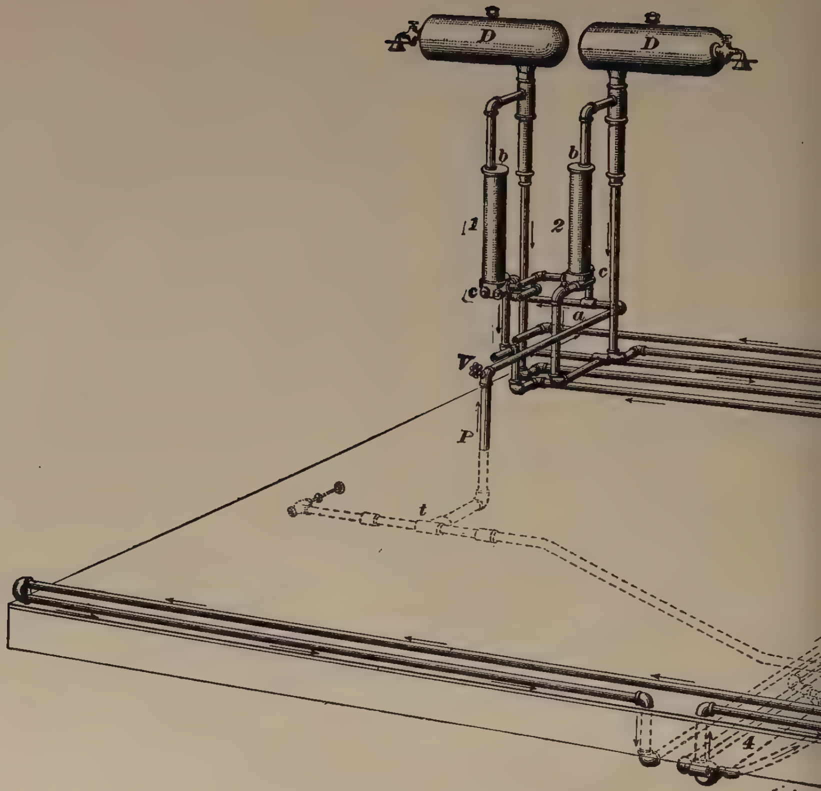
When approaching a station where cars are to lay over, open all the steam and drain valves throughout the train, beginning with the rear car; do this 10 minutes before reaching the station. If the train is a long one, have extra steam pressure for this purpose; 5 minutes before reaching the station, open the rear train-pipe valve; 3 minutes before reaching station, shut off steam. Uncouple all hose when engine is cut off.

When taking extra cars on a heated train, couple up all the hose, open the train-pipe valves, blow out the train pipe of the fresh cars, and then proceed to heat them up as just described. If the cars are intended for the front part of the train, blow steam through them from the engine before coupling up to the rear cars.

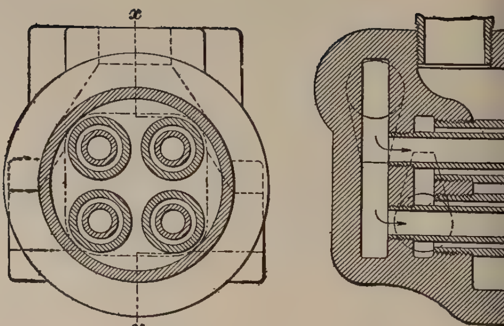
---

## CAR EQUIPMENT: HOT WATER

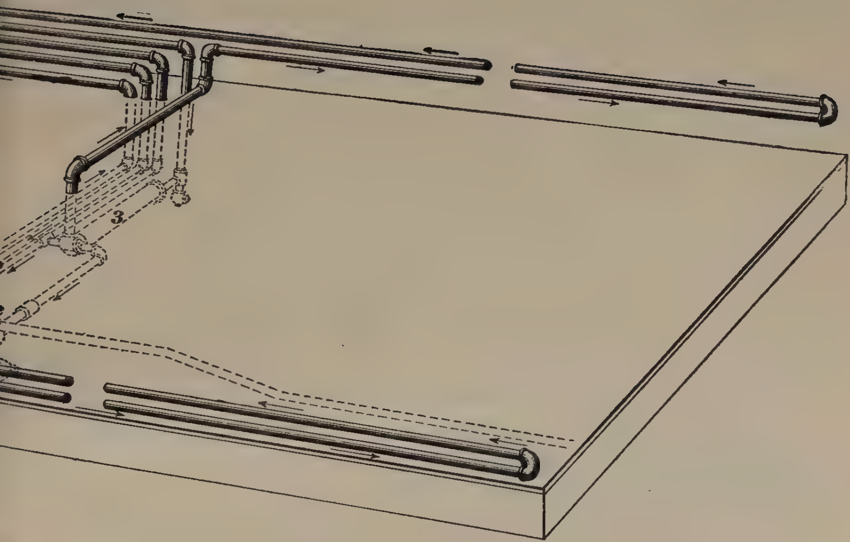
**24. Closed-Circulation System.**—Fig. 18 (*a*) illustrates the Consolidated Company's **closed-circulation hot-water system**, as used in conjunction with the Baker heater or similar apparatus. Steam in the train pipe passes from the fitting *t*, through *P* to valve *V*, which controls the supply to the heater. From *V* it passes through pipe *a* to the heating jackets *1* and *2*, which it enters. These heating jackets consist of a section of wrought-iron pipe *b* with cast-iron heads *a* and *f*. Inside the iron pipe are four sets of

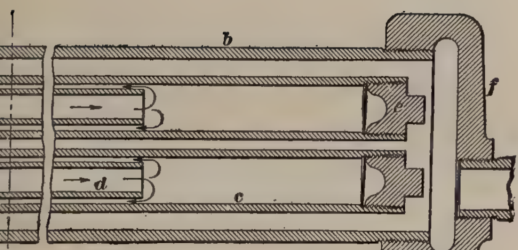


(a)



(c)




(b)

copper pipe, one inside the other, views (*b*) and (*c*). The steam passes up the smaller copper pipes *d* and down the larger ones *c*, as shown by the arrows, imparting its heat to the water from the circulating pipes, which passes through the pipe *b*. After traversing the jackets in the car it passes to the jackets *3* and *4* under the car; from there it passes away at the trap as condensed water. The water of circulation in passing through these four jackets is heated to the proper point to warm the car.

There is an independent line of radiating pipes on each side of the car, which are shown in view (*a*). There is a separate expansion drum for each side and two heating jackets, one in the interior of the car on the riser to the drum and one jacket under the car for each side. One trap takes care of the condensation of all four jackets, the condensation from jackets *1* and *2* going with the steam to jackets *3* and *4*, then to the trap.

The expansion drum is provided with a safety valve. With all new equipment this is a metal seated valve provided with a spring and screw plug to adjust it for the proper pressure, which is 125 pounds per square inch. To adjust the pressure, slacken the nut on the top of the device, and screw down the plug to increase the pressure, and unscrew it to lessen same. Then lock by means of the nut. If the spring inside should get coated with salt deposit, remove the whole fitting from the drum and soak it in hot water; clean the seat of the valve and replace.

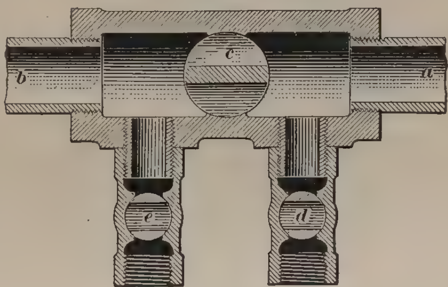



FIG. 19

**25.** The special **filler cock** is shown in section in Fig. 19. It should be placed in the lowest point of the system and as near the Baker heater as practicable; a double circulation requires two. The circulation piping is connected

at *a* and *b*, the latter being the end and nearest the Baker heater; *c* is the main cock, and *d*, *e* two draw-off cocks. The figure shows the device in its usual position—open.

To blow out obstructions in the heater pipes, close the cock *c* and open *d* and *e*. Connect steam with *d* and leave *e* open until everything is thoroughly blown out.

To fill the pipes, close *c* and pump water in at *d* until it flows out clear and freely at *e*. Continue this until air and dirt have been driven out of the pipes. Then close *e* and *d* and open *c*, bringing the device into the position shown in Fig. 19, which is its condition at all times, except when blowing out or filling the pipes. The position of each of the cocks is denoted by a groove on the end of the shank, each groove running in the same direction as the opening in the cock.

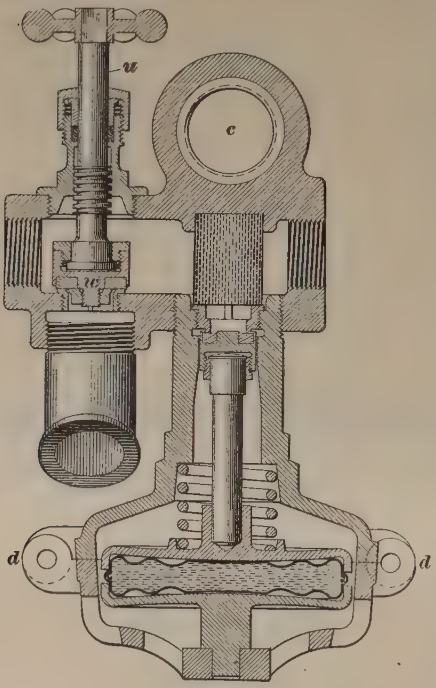


FIG. 20

**26.** Fig. 20 shows the trap used in connection with the heating jacket *J*, Fig. 18. It is arranged so as to have a hot metallic connection with the train pipe at *c*. A chamber is provided to catch the sediment, which can be blown out through valve *w*. The strainer prevents dirt or scale getting on the seat of the valve of the trap. *c* is the train pipe, the heat of which keeps the trap warm. The casing is hinged and fastened at *d d*, so that it can be opened and the thermostatic cell, or the valve and its seat, readily removed.

**27.** To heat the train, open the steam valve $V$ slowly until it is wide open. Have the drain valve $u$ open for about 1 minute when steam is first turned on, or long enough to discharge all the condensed water, and then close it. The temperature of the car may be adjusted by means of the steam valve. When steam is not being used, all valves should be left open.

**28. Commingler System.**—In this system, the Baker heater pipes are used, as before, but instead of the steam heating the water by passing through jackets inside of which run the heater pipes, it actually mingles with the water that it is intended to heat; hence, the name given to the system. In heating by means of jackets, it generally happens that some of the steam discharges before being condensed; thus much heat is wasted. In the present system, however, the steam is all condensed and brought down to the temperature of the circulating water before it is discharged. The present system is an **open-circulation** one, as distinguished from those already described, wherein the circulating water remains the same, having no outlet nor inlet while the system is working, being shut off, in fact, from all communication with air, steam, or water, and therefore spoken of as a *closed*, or *sealed*, circulation.

Fig. 21 shows the piping and fittings used in the **commingler system.** Steam is taken from the train pipe $P$ at the fitting $t$, whence it passes through pipe $P'$ to the side of the car and runs to the heater end, where it turns upwards until it reaches fitting $t'$; thence it passes the dial cock $c$ which regulates the flow of steam for that car, and ascends to a point about level with the top of the expansion drum, making the turn at $f$, and descends to the commingler $C$, just before reaching which it passes through the strainer $j$. Entering the commingler, it mixes with the water, as hereafter described; the heated water leaves the top of commingler $C$ and goes through the riser $R$ into the expansion drum $D$. From the drum, it descends through the downflow pipe $p$ and makes the circuit of the car as indicated by the arrows. The

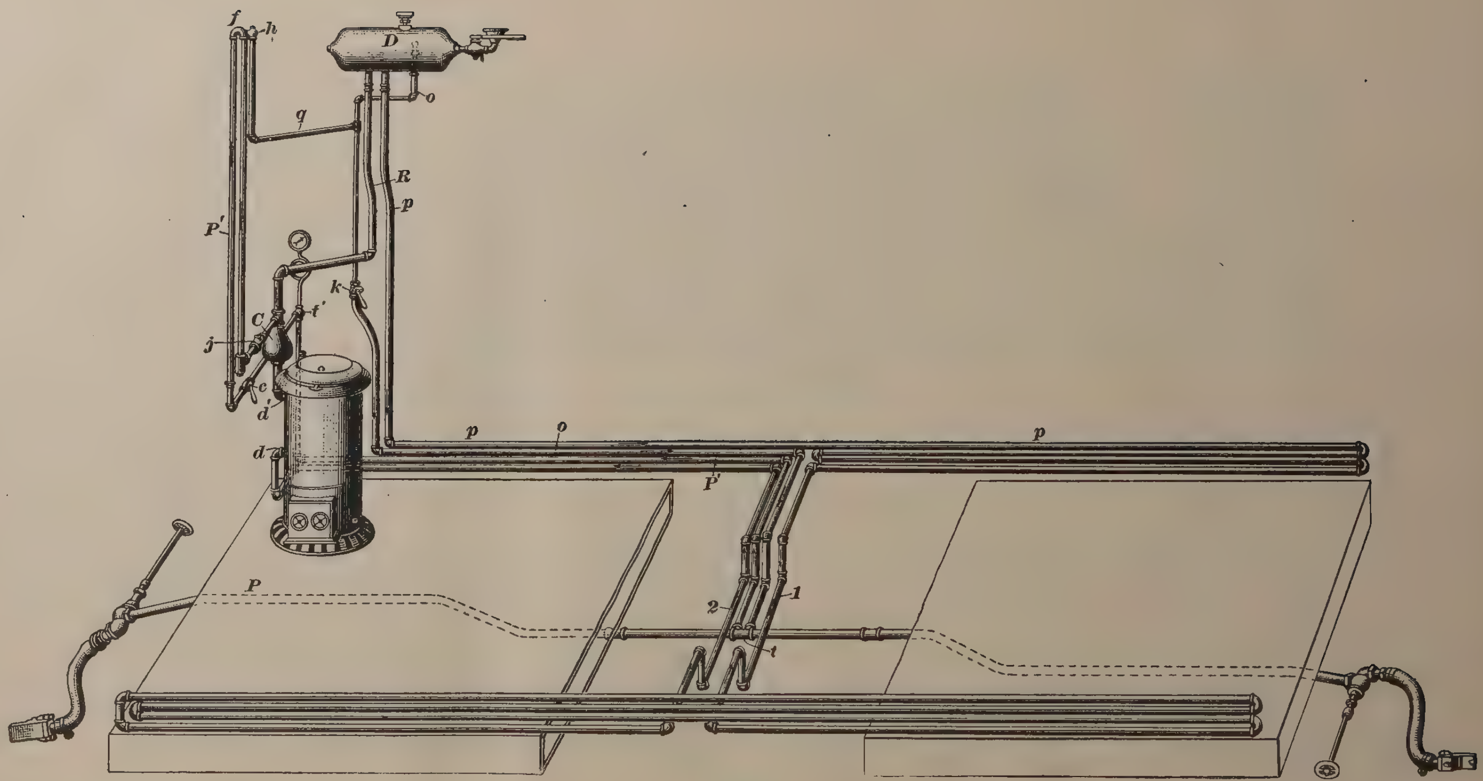



FIG. 21

water crosses the car through pipe *1* and recrosses it on its return through pipe *2*, entering the bottom of the heater coil at *d*, passes through the coil and out at *d′* into the bottom of the commingler, and thence into the drum again.

In this system, there is a continual addition being made to the amount of water in circulation, owing to the constant condensation of steam in the commingler, as a result of which the drum *D* gradually fills. When the water in it rises to a certain height, it overflows into the pipe *o*, through which it passes down and along the car to the fitting *t* in the train pipe, and thence out through the drip pipe. As the connection for the drip pipe is close to the live steam in *t*, the drip cannot freeze.

Water is kept from running back from the drum to the train pipe, when changing engines or when using fire instead of steam, by carrying the pipe *P′* above the level of the water in the drum and then bringing it down again to enter the commingler. In the fitting, *j* is a swing check-valve opening toward the commingler, thus preventing the water passing back from the latter up pipe *P′* and so to the train pipe. So, also, if the train were to part or the train pipe become uncoupled, the pressure of steam in the expansion drum would force the water through *R* and *P′* to the train pipe but for this check. However, unless the trap cock *k* is closed before shutting off the supply of steam to the train pipe, the expansion of the water in the system will force some water out of pipe *o* to the drip at *t*. This will reduce the water level in *D* considerably in case the water in the circulation is very hot. There should be as much perpendicular distance as possible between the commingler and expansion drum to get good results from this system.

When fire is being used in the heater, instead of steam, the cock *c* must be kept closed, as must also the trap cock *k* in the overflow pipe *o*. The purpose of the pipe *q* is to allow air to enter the steam pipe *P′* to prevent a vacuum forming when steam is shut off from the system and the steam in the train pipe condenses. As soon as a vacuum forms, the diminished pressure in the train pipe and steam

pipe allows atmospheric pressure, which is then the greater, to force air through the drip pipe and along the overflow *o* and through *q* into *P′* after lifting the check-valve at *h*; in this way air enters the train pipe on each car. As a matter of fact, a small quantity will also enter the train pipe through the groove in the seat of the rear train-pipe valve; but this, in itself, will not admit sufficient air promptly to the train pipe. On the top of the overflow pipe *o* is a cap, open at the side, so designed that it will allow the water to pass off when a certain level has been reached, but at the same time prevent the escape of water thrown up by the action of the commingler. This pipe *o* should be at least 12 inches from the riser *R* inside the drum.

**29.** Fig. 22 shows a section of the **commingler.** Water from the heater coil enters through the pipe *d′* and leaves through *R* on its way to the expansion drum. Steam from the train pipe enters at *p′* and passes down pipe *a*, escaping thence into the body of the commingler through the small holes shown in the nozzle *b*. The admission of steam to the body of the water in this manner prevents the noise that is experienced when steam enters a body of cold water directly and without being previously broken up, as is done by these holes.

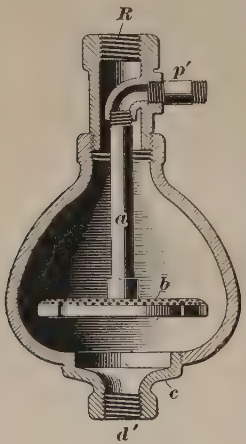


FIG. 22

**30.** To heat a train with steam, see that all the steam hose is coupled up and all the train-pipe valves open. Then turn on steam from the engine, and when it blows freely out of the rear-end coupler, partly close the rear train-pipe valve, leaving it open just enough to keep the rear end of the pipe from freezing. Next open the trap cock of the rear car full in the heater room, and the dial cock just enough to heat the car to the proper temperature. Follow up with the other cars of the train working toward the engine. When steam

cannot be obtained, a fire must be kept in the heater, observing to shut the dial cock and trap cock.

If the overflow pipe from the drum is clear, the condensed water will begin to escape soon after the steam is turned on. It should be noted whether this occurs or not. When within about a mile of a station where the engine is to be cut off or where cars are to be taken on or off, the rear train-pipe valve should be opened and steam shut off at the engine. When approaching a point where the train is to be delivered up to another road, shut the dial cock and trap cock before opening the train-pipe valve at the rear end of the train pipe. This should also be done on every occasion when steam is to be shut off for more than 5 minutes; while if the time exceeds 20 minutes, the steam hose between the cars should be uncoupled. To assist in carrying out this rule, steam should not be shut off at the engine without first notifying the trainmen. Whenever a train is without steam, the train-pipe valves should be left wide open. Trainmen will note this when setting out cars. Whenever it is necessary to use fire in the Baker heater, the dial cock and trap cock must be closed, and if the car or cars are at the rear of the train, the steam hose must be uncoupled between the cars themselves, and also between the first dead car and the last car using steam.

**31.** When the circulation fails and the trainman is unable to restore it, and finds that the car is getting cold, he should shut the trap cock and open all drain cocks under the car; this will allow water to run out of the heating pipes and live steam to enter and heat the car.

If a car loses some of its water and the circulation stops, shut the trap cock until the system fills up again by steam condensing. If this does not answer, fill up at the next station stop, shutting the dial cock and opening the trap cock when nearing that station, to allow the steam to escape from the drum and riser pipe.

If steam has been on continuously for any length of time and the overflow is not hot, it is an indication that it is

stopped up somewhere. Since with an obstructed overflow water cannot discharge from the drum, the result will be to prevent hot water circulating in the car. When such a case arises, try the effect of reversing the handle of the trap cock, turning it around from "open" to "open"; then, if the small hole of the cock is choked up, the dirt will be carried out and the pipes get hot. If unable, however, to remedy the trouble, and the demand for heat is imperative, shut off steam at the dial cock and stop at the next station. Here drain half the water out of the drum at the filler cock, close the trap cock, and light a fire in the heater. If the drum is inside the car, this can be done without waiting for the next stop.

If while steam is on, a car is found to be getting cold, first see that the dial and trap cocks are open. If so, feel if the steam pipe $P'$ near the heater is hot; if it is, and the gauge shows a pressure, it is a sign that this pipe is all right. Next feel the overflow pipe; if unobstructed, it also will be hot.

If a car is found to be cold, and the dial and trap cocks are open and the steam and overflow pipes are hot, feel the pipe under the commingler; if it is hotter than the down pipe or than the pipes at the other end of car, it is evident that circulation has stopped, and the trap cock must at once be closed. By closing this cock, steam is kept from escaping from the drum; it will therefore condense and refill the system. If this is effectual in restoring the circulation, such will be shown by the pipe under the commingler becoming cooler.

If the weather is very cold, and circulation is not restored in time, the cross-over pipes may freeze; where this seems probable, stop at the next station and fill up the expansion drum, being careful to shut the dial cock and to open the trap cock before the station is reached. This will let out the steam and so enable water to be put in without delay; the train should then start away again without further loss of time and without waiting to see if circulation is restored. If the circulation is still found to be at a standstill, stop at the next station and open the drain cocks in the cross-over pipes, first thawing them with a torch, if necessary,

and blow them out, as it may be that mud is the cause of all the trouble. If all efforts still fail, leave these cocks open just enough so that the condensed water and a little steam will come out at each one. If steam does not come out at any one of the drain cocks leave it wide open, shut the trap cock, and use dry steam.

**32.** Each road has its own rules for cleaning out its piping, both as to frequency and also the method of doing it; the majority clean them out once a year. Following is the method adopted by the Canadian Pacific Railway, who are large users of this system: Take down the commingler, disconnecting the various pipes; connect a piece of hose with the open end of the riser, and attach a pipe to end $d'$ to lead the water from the car. Then turn on water from the water main, allowing the full force to act; and the water, after making the circuit of the system, will escape out of the top of the coil through $d'$ and the water pipe just mentioned. While this water is passing through the pipe, tap lightly but smartly on the pipes, particularly the cross-over pipes and heater coil. Remove the lower part $c$ of the commingler, Fig. 22, take out the steam nozzle and clean it, removing any dirt that may be inside; see that the pipes $a$ and $P'$ are clean, and reassemble the parts. Disconnect the overflow and take the overflow cap out of drum; see that the openings in this cap are clean. Examine the trap cock; see that it is tight when closed and that when open a $\frac{1}{8}$-inch wire will pass through it freely. This cock should show perfectly tight under a warm-water test, using a pressure of 250 pounds kept on for 20 minutes. The dial cock should be similarly tested. If these cocks are not tight, and it is found that tightening up the flange bolts does not make them so, they require new packing. See that the check-valves at $c$ and $h$ are clean; they should open and shut freely and also be quite tight on the seat. Examine the strainer in the fitting $s$ at the bottom of the pipe $P'$. Take out the plug in the lower end of the fitting, remove the strainer, and see that it is quite clean and the holes all clear. The parts can now be connected and the

pipes filled as previously directed; if there is a filler cock in the cross-over pipe, as shown in Fig. 19, proceed as detailed in Art. **25**, after which steam may be turned into the commingler to start the circulation and free the pipes from the air that will have remained in them.

## WATER-RAISING SERVICE FOR COACHES

### INTRODUCTION

**33.** Until within the last few years, passengers using car lavatories had to raise water in the lavatories by means of a hand pump. Then began the practice of taking compressed air from the brake system to force this water through the faucets into the wash bowls.

As this device involved the withdrawal of air from the brake system, much trouble and annoyance was caused through badly designed methods of utilizing this air, and as a rule the enginemen and trainmen were unacquainted with the piping used, and therefore could not locate the trouble at its source. If the supply for this system had to be drawn from the main reservoir—the proper source—it would necessitate an extra train pipe with the necessary hose couplings. In the absence of this, the supply had to be taken either from the ordinary train pipe or else from the auxiliary reservoir; the latter was the course adopted.

It is known that the brake will not set as long as the pressure in the auxiliary and train pipe remain equal, but if the train-pipe pressure is reduced or the auxiliary-reservoir pressure increased, the triple valve will be actuated and set the brake; also, a reduction of auxiliary pressure when the brake is set will release the brake. We can thus see the objections to a system that takes air from either the auxiliary or the train pipe and that also, through leakage, will allow air to go back into the train pipe or auxiliary. In the one case it may

release the brakes, and in the other set them harder. In addition to these drawbacks, water might leak into the brake system. All this has in the past given considerable trouble.

---

### EARLY ARRANGEMENTS OF APPARATUS

**34. First Method.**—In the first cars equipped with water-raising apparatus, there were three water tanks—piped together top and bottom—and one air tank. Air was taken from the train pipe and conducted through a valve and pipe into the bottom of the air tank, from whence it passed into the upper part of the water tanks, exerting therein a pressure tending to force the water out along the supply pipe in the car. Check-valves were provided to prevent any return of air from the air or water tanks to the train pipe, but all such valves are liable to leak at times, and when this was the case, air from the air tank would leak back into the train pipe and by raising its pressure would release the brakes. In ordinary stops, where the application of brakes last only for 10 or 15 seconds, leaks of small magnitude will produce no ill effect, but they are a serious item when the train is working down long mountain grades where the brakes must be kept on for 30 to 40 minutes at a time. Long intervals such as these will, of course, enable even small leaks to release the brakes against the engineer's intentions. In like manner, also, water can leak into the brake system, where it will interfere seriously with the operation of the brakes.

**35. Improved Method.**—The foregoing consideration led to the introduction of another arrangement, in which, although air was still taken from the train pipe, it was permitted to do so only during station stops of several minutes duration. This procedure was a recognition of the undesirability of taking air from the brake system at any and all times. It was so arranged that when the tank lever was pulled out for the purpose of refilling the tanks, communication was shut off between the air tank and the water tanks, and also between these latter and the distributing pipes; at the same time the supply pipe and vent pipe to the water

tank was opened and communication established between the water tanks and the atmosphere. By this arrangement water could be run freely into the water tanks, while at the same time the water remaining in the distributing pipes and the air in the air tank were prevented from escaping. On pushing in the lever, the supply pipe became cut off from the water tanks, the latter were shut off from the atmosphere, and communication was once more opened up between the air and water tanks and between the latter and the distributing pipes.

The air in passing from the air tank to the water tanks had to go through a reducing valve or regulator, which cut down its pressure to the desired amount; 70 pounds was carried in the train pipe, but this was much more than required in the water system. Using it at that pressure would only result in splashing when the faucet was opened. Consequently, this valve was set to reduce the pressure to 20 pounds.

A shut-off cock was now placed in the pipe leading from the train pipe to the air tank, and, as remarked, this cock was enjoined to be opened only when standing at stations, and to be kept closed when the train was running. Just beyond this shut-off cock, between it and the air tank, was a stopcock; to the nipple leading out of this cock a hand pump could be attached and air pumped into the air tank on occasions when air pressure could not be obtained from the brake system. The success of this method depended on the trainmen obeying the injunction to keep the shut-off cock closed while the train was running. Sometimes they neglected to charge the system while the train was at stations, or perhaps the air pipes were not tight and therefore air was lost through leakage. In such cases, seeing the pressure go down, the trainmen, instead of pumping it up by hand, were wont to open the shut-off cock and take air from the brake system. In some cases they would know enough of the action of the apparatus to take air very gradually, thus not entailing any ill result, for the pump governor would keep the pump going and so keep the train-pipe

pressure from reducing rapidly enough to apply the brakes. Often, however, the cock would be opened abruptly and the brakes applied as a result—sometimes "in emergency."

Again, the regulator would not always act properly, and sometimes it would prevent any passage of air from the air tank to the water tanks, thus taking away the lifting force necessary to put water into the basin. Often the shut-off cock would be left open, more or less; in such cases, if the automatic valve was not tight on its seat, it could not prevent the return of air from the air tank, and thus when train-pipe pressure was reduced to apply brakes, air would go back past the shut-off cock into the train pipe and release the brakes. This made the arrangement as objectionable as the one first described.

### MODERN ARRANGEMENTS OF APPARATUS

**36. First Method.**—Fig. 23 shows one of two modern methods used for raising water; it differs from the two already described in the fact that it draws the air pressure from the auxiliary reservoir instead of from the train pipe. This was done so as to avoid the evils resulting from taking the air from the train pipe, which affected all the brakes, while taking the air from the auxiliary only affects one.

In the illustration, $A$ is the auxiliary reservoir; $B$ the brake cylinder; air passes from $A$ through pipe $P$ to the air tank $C$, first passing through the governor valve $g$. The purpose of this valve is to prevent air under 60 pounds pressure passing through from the brake system, thereby insuring that sufficient pressure will accumulate in the auxiliary reservoir to test the brake before the supply is drawn on by the air tank. Air, on leaving the air tank to go to the water tank $D$, must pass through the reducing valve $r$, and thence through pipes $p, p'$ to the water tanks. The reducing valve $r$, which corresponds to the regulator mentioned in connection with the earlier systems, is adjusted to 20 pounds, that being the limit of pressure allowed to pass to the water. The passage of air in this direction is controlled by cock $c$, whose levers $l$ are operated from either side of the car. The other cock

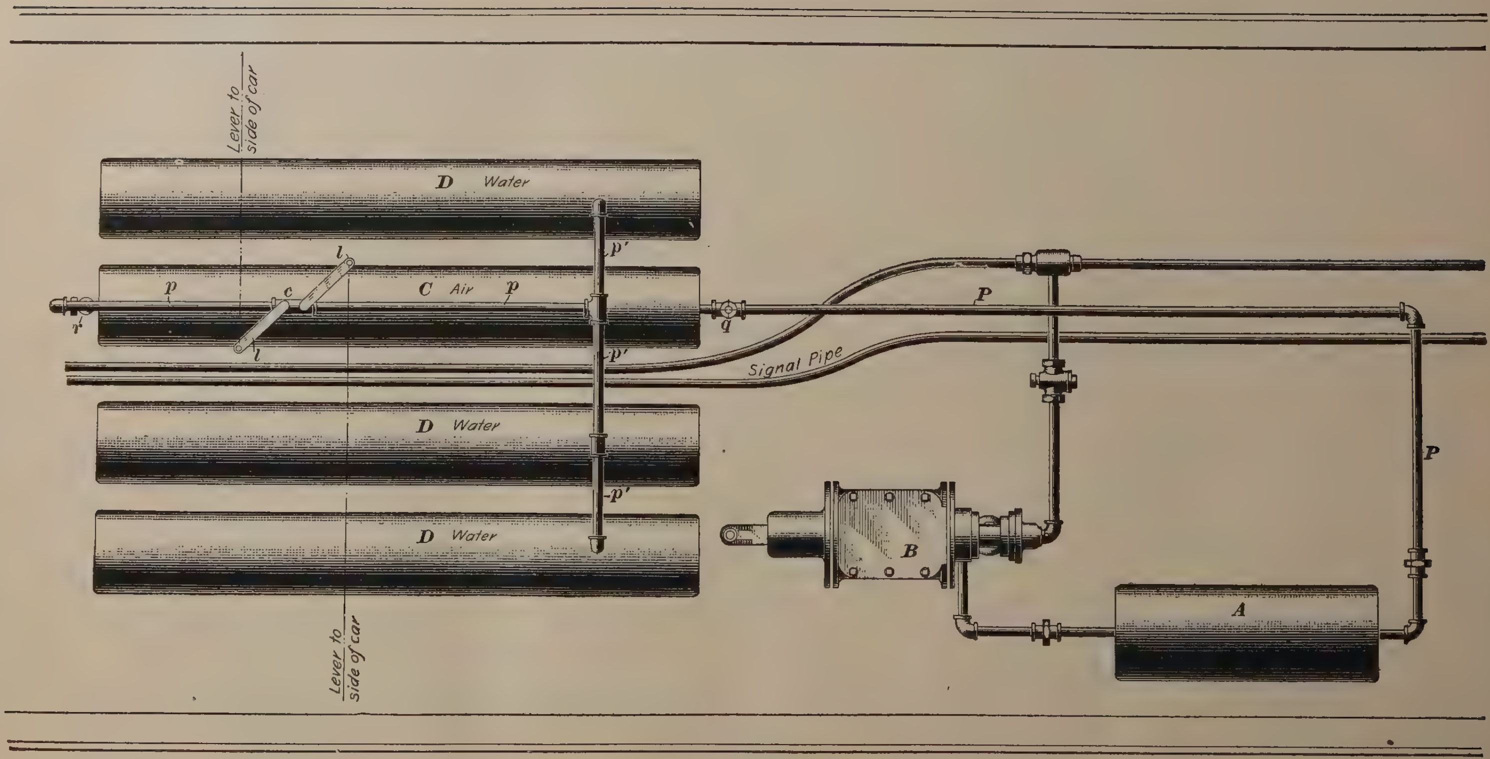


FIG. 23

connections are the same as in the earlier systems. As regards the time required to charge the tanks *C*, *D*, it will be borne in mind that all the air that goes to these tanks must first pass through the feed groove in the triple valve. The governor *q* prevents any air going through to the air tank

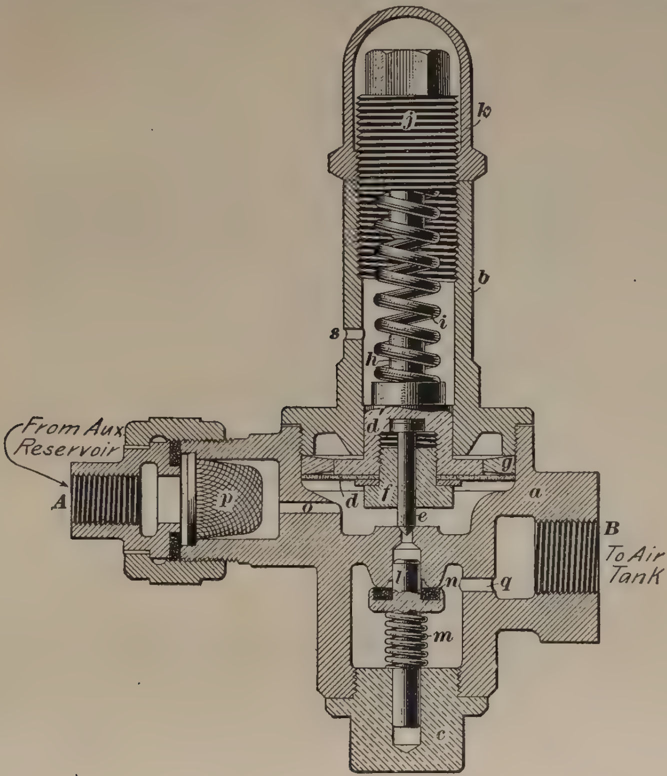



FIG. 24

until a pressure of 60 pounds has accumulated in the auxiliary; this controls the rate of flow and keeps the communications closed when, in using the brake, the auxiliary pressure is below 60 pounds.

**37. Air-Pressure Governor.**—Fig. 24 shows in section the latest form of air-pressure governor used at *q*, Fig. 23. The parts as marked are *a*, thé body; *b* and *c*, the

upper and lower caps; *d*, the diaphragm; *e*, the diaphragm valve, held in the diaphragm plate *d′* by means of the nut *f*. The diaphragm is held air-tight by the ring *g*, screwed down by cap *b*. The pressure on diaphragm stem *e* is supplied by spring *i*, the tension of which is regulated by the plug *j*, locked in position by the jam nut *k*. The supply valve *l* is held on its seat *n* by spring *m*. Air comes in at *A*, and after passing valves *e*, *n* goes through *q* to the air tank, the other side *A* of the governor being piped to the auxiliary reservoir. The valve *e* is moved up and down by air pressure on the diaphragm plate *d′*, the diaphragm allowing flexibility of motion while also preventing the pressure from getting on its top side. The spring *i* is screwed down by means of the plug *j* until it requires an air pressure of 60 pounds per square inch to raise the diaphragm, and so lift valve *e* off its seat. When this occurs, the air flows past *e* and forces the valve *n* down against the resistance of spring *m*, and passes on through port *q* to the air tank. The stem *l* of the valve *n* is a neat fit so that air will flow by it slowly and not reduce auxiliary pressure too fast. Air cannot come back from this tank to the auxiliary reservoir on account of the valve *n* acting as a check, for if the pressure in the auxiliary were to get less than that in the air tank *C*, the greater pressure in the latter would keep *n* firmer on its seat. Of course, if valve *n* leaks, its value as a non-return check is gone; and this is one of the things that must be watched, for then the air will flow back into the auxiliary, prevent the release of the brake, and probably cause the wheels to be skid. The hole *s* is to allow the escape of any air that may leak through to the upper side of the diaphragm, thus preventing the accumulation of pressure there.

**38. Reducing Valve.**—The reducing valve is shown in section in Fig. 25. Connection with the air tank is made at *C*, and at *D* with the pipe leading to the water tank. The object of this valve is to reduce the pressure to 20 pounds per square inch before it goes into the water system. In the figure, *a* is the valve body; *b*, *c*, the upper and lower

caps; *d*, the piston, forced down by air pressure in tank and forced up by the adjusting spring *26*. The supply valve *l* is moved to its seat by the spring *m*. Now, when all pressure is off, the piston *d* is up and the end of its stem *25* presses on the stem of the supply valve *l* and so keeps the latter off its seat, ready to admit air to the water system. This air

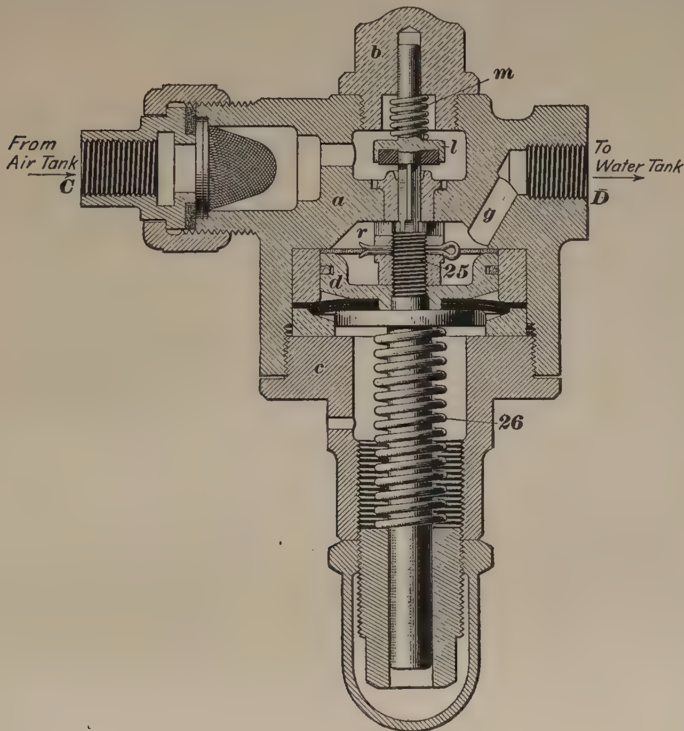



FIG. 25

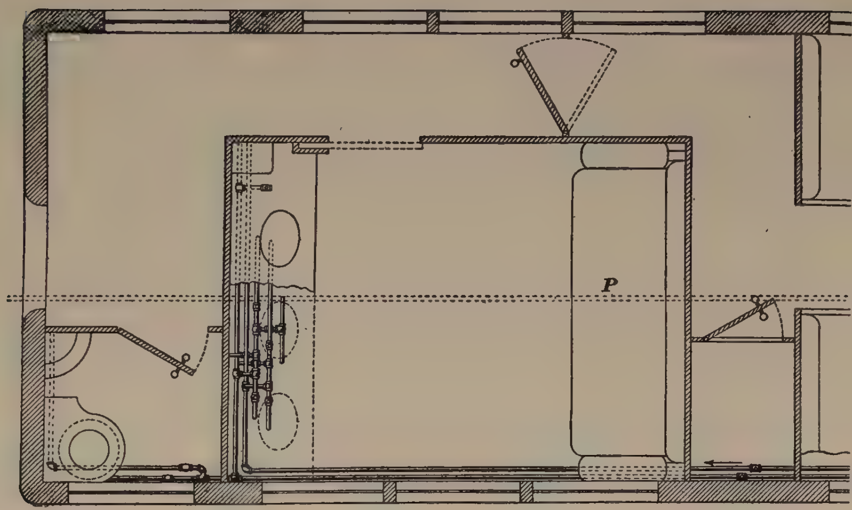
comes from the air tank or reservoir at *C* and passes by the seat of valve *l* and so into chamber *r*, and thence through passage *g* to the water tank. When the pressure in the tank, and therefore in chamber *r*, exceeds 20 pounds per square inch, the pressure on the piston becomes greater than the resistance of spring *26* and moves it down, allowing valve *l* to seat and shut off all further flow of air to *r*

and the water tank. When, through leakage or the use of the lavatory, the pressure in the water tank and chamber *r* falls below 20 pounds, the piston is pushed up by the spring *26*, thus unseating the valve *l* and once more allowing air to flow past *l* into *r* and on into the water tank *D*. If the face of *l* should get dirty and not seat tightly, an excess of air will pass into the water system, unduly robbing the auxiliary reservoir and causing a violent splash when passengers open the faucets.

---

### SYSTEM NOW IN USE

**39. General Description.**—The system now being installed involves many improvements over those already shown, both as regards the water and also the air supply. It is illustrated in Fig. 26, wherein it will be seen that with a view to economizing space, a single water tank replaces the three tanks hitherto used, and is placed in line with the air tank. Of the views here given, (*a*) is a plan of part of the car; (*b*), a side view; (*c*), a cross-section through end *E* of the tank box; (*d*), a side view of the right-end portion of the car; (*e*), an end view of the same, showing the heating arrangements. Of the parts lettered, *A* is the auxiliary reservoir; *B*, the brake cylinder; *C*, the air tank; *D*, the water tank; and *P*, the train pipe belonging to the brake system. The cold-water fittings are: *a*, view (*a*), the shut-off cock in the supply pipe; *b*, view (*d*), the stop-cock and waste cock for the closet; *c*, *c*, the stop-cocks for the wash bowls; *d*, the stop-cock for the faucet; *e*, the stop-cock for the fire-hose. Among the hot-water fittings are *f*, view (*a*), the shut-off cock in the supply pipe; *g*, *g*, view (*d*), the stop-cocks for the wash bowls; *h*, the shut-off valve for the hot-water coil; *i*, the check-valve in the supply pipe leading to the hot-water coil *j*; *k*, the shut-off valve in the hot-water supply pipe leading from the heater; *l*, the drip stop-cock in the pipe leading from the hot-water coil; *m*, the safety valve on top of the hot-water tank *n*. The main shut-off cock is marked *o*, view (*b*), and is operated from the inside


P

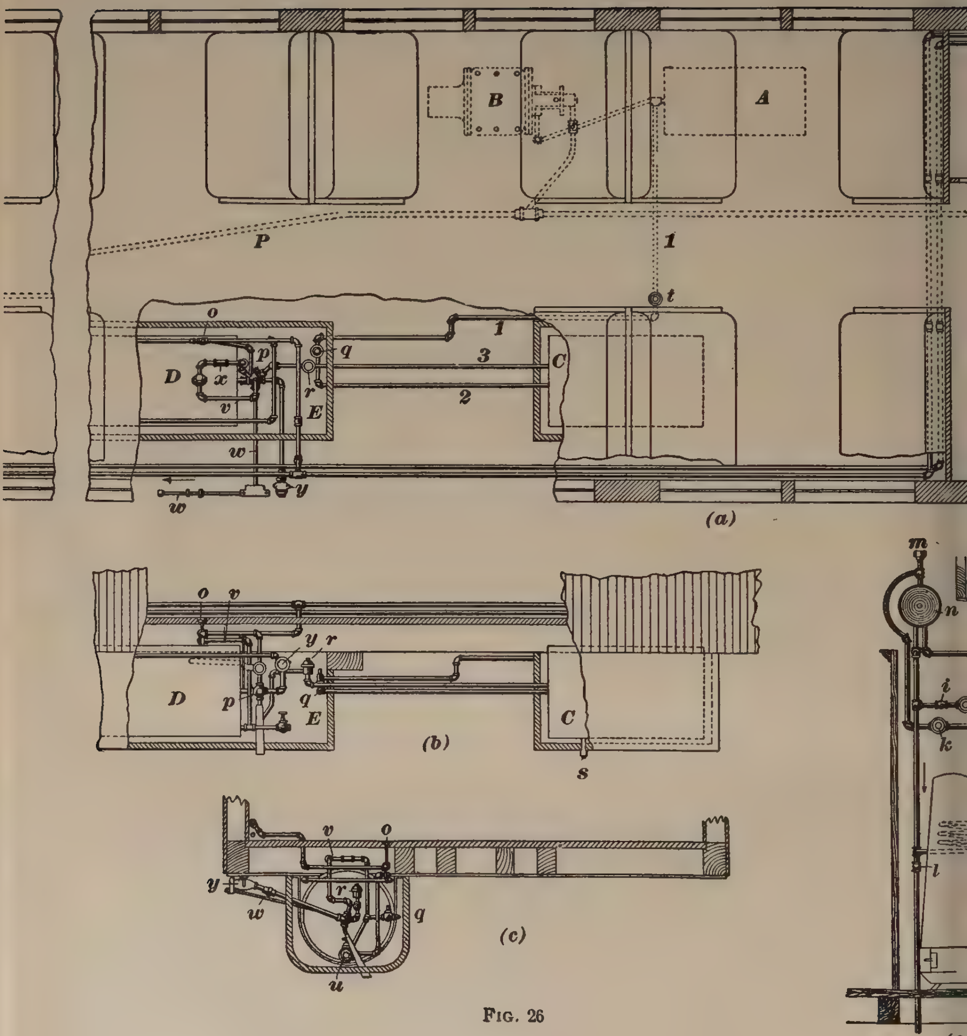
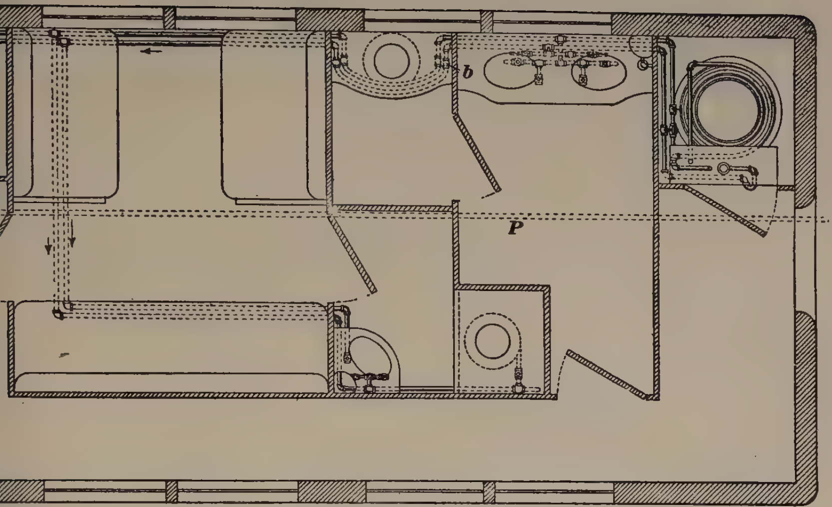
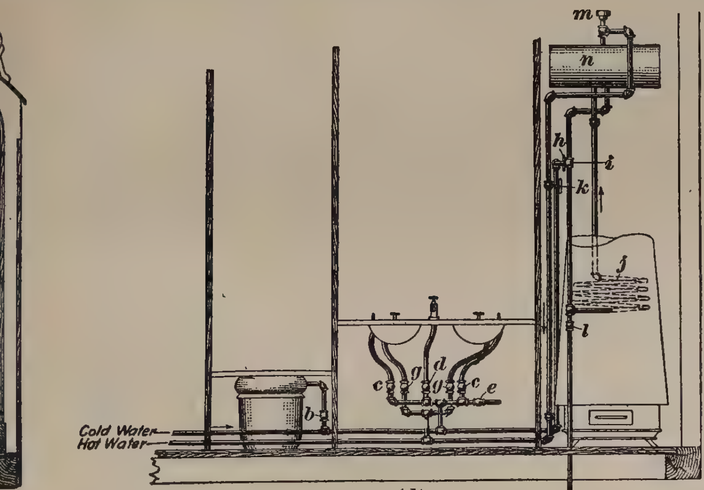



FIG. 26




(d)

of the car; *p* is a combination cock serving to admit water into the tank *D* when filling, and also, subsequently, to admit air from tank *C* to *D*; *q* is the air-pressure governor; *r*, the air-pressure reducing valve; *s*, the drip cock in the air tank; *t*, view (*a*), the drip cup, with strainer, in the air pipe leading from the auxiliary to the air governor; *u*, view (*c*), the waste pipe and valve from the water tank; *v*, the air vent from the water tank; *w*, view (*a*), the stem for operating cock *p*; *x*, the check-valve in the air-pressure pipe; *y*, the tank filler.

**40. Action of Apparatus.**—Air passes from the auxiliary reservoir *A* through the pipe *1* to the governor *q*, which allows no air to pass until a pressure of 60 pounds is reached. Thence, air goes through pipe *2* to the air tank *C*, which it leaves by way of pipe *3* on its passage to water tank *D*. After passing through the reducing valve *r*, the air reaches the three-way cock *p*, which controls its entry into tank *D*. After passing this cock, it enters the top of tank *D*, first passing the check-valve *x*. From tank *D*, the water passes through the main shut-off cock *o* on its way to the wash rooms. If the pressure from the faucets should be too great, it can be controlled by the cock *c*, view (*d*), underneath the wash stands. Closing the cock *o* shuts off the whole water supply to the car. Water can be shut off from either end of the car separately by means of cocks *a* and *f*, view (*a*), the former for cold water and the latter for hot. By means of cock *k*, view (*d*), the hot-water supply can be shut off entirely. The hot-water tank *n* may be drained off by means of the cock *l*.

**41. Operating the System.**—To fill the water tank, the air supply from the air tank must first be shut off, and the air that is already in the water tank allowed to escape. This is accomplished by turning the stem *w* of the combination cock to the right, which at the same time opens the way for water to enter the tank when put into the filler *y*. Generally, a hose is used for filling; if buckets are used, a funnel supplied for the purpose should be attached to the filler. If

water is exhausted in tank *D*, it is indicated by air coming out of the faucets.

One of the important points in running this system is to see that the reducing valve *r* is in good working condition, as otherwise full air-tank pressure will pass to the water, which will not only be an annoyance in itself, but will also waste air, the renewing of which entails extra work on the pump.

To test the reducing valve, charge the air and water tanks, and note the pressure indicated by the gauge in the wash room; it should not exceed 20 pounds. If no gauge is found, first open cock *C*, view (*d*), then the faucets, and note the flow of the water into the wash bowls.

To test the governor, charge the tanks as above; the black gauge hand should show 20 pounds, and the red hand, 70 pounds. Then close the angle cocks at both ends of car and disconnect the hose; next open the release valve in the auxiliary reservoir and draw off all air pressure from the auxiliary and the train pipe; close the auxiliary release valve for a few minutes and again open it. If no pressure has accumulated, the valve *l*, which prevents return of air, is tight on its seat. The actual pressure to which the governor is adjusted can be ascertained by attaching a gauge to the auxiliary.

As already remarked, if air without water escapes when the faucet is opened, the water tank requires refilling. If neither air nor cold water escapes, see that all the cocks *a*, *c*, and *d* between the water tank and wash stands are open. If hot water fails to appear, see that cocks *f* and *g* are open and also valves *h* and *k*. Cock *l* should be shut; if open, it will empty the hot-water tank.

Sometimes it may happen that although the cocks are all right and there is plenty of water in the system, yet no air pressure is apparent. In that case, the strainer and drip cup *t* in pipe *1* should be examined, and also the governor and the reducing valve. The latter should be examined first when trouble arises through the flow being either too weak or too strong, as it can, in the event of dirt or bad adjustment, give

rise to either of these troubles. It is a good plan to drain the air tank after each trip by means of the drain cock.

In some cases, the air gauge on the engine may be incorrect and indicate a train-pipe pressure of 70 pounds, while this pressure may be less than 60 pounds. In such a case, the governor being set at 60 pounds, no air will pass into the tank. The remedy for this trouble is to raise the train-pipe pressure and see if it affects the flow of water, and thus locate the trouble.

# ELECTRIC HEADLIGHT

## THE PYLE-NATIONAL HEADLIGHT

### DESCRIPTION OF ENGINE AND DYNAMO

**1.** In keeping with the general advance made in locomotive construction, there has been created in the last few years a demand for a headlight of greater illuminating capacity than the old-style oil lamp. While it will be some time, perhaps, before freight engines are provided with electric headlights, yet the general adoption of this light for passenger engines makes it essential that those responsible for the care and operation of locomotives gain a knowledge of this apparatus sufficient at least to insure the proper handling necessary to avoid its failure on the road. This headlight passed the experimental stage some years ago, and is now used to such an extent as to admit of its being classed with the more familiar apparatus—the injector, lubricator, air brake, etc.—and, with the same care and intelligent operation, it will render as efficient service as any part of the locomotive, or any of the locomotive attachments.

**2. General Description.**—Briefly, the electric headlight consists of a self-contained engine and dynamo and an arc lamp. The engine provides the power necessary to operate the dynamo, which in turn generates the electric current that operates an arc light that is provided with a suitable reflector, in the same manner as the ordinary oil lamp. The engine and dynamo are direct connected, the connection being made through the medium of a steel shaft revolving in suitable bearings that are carried by a body or framework of iron.

This frame, though lightly constructed, is of ample strength, as the parts are perfectly balanced and have a rotary movement throughout. By this explanation, it will be understood that the motion (1,800 revolutions per minute) of the dynamo is directly transmitted from the engine without the intervention of any speed-multiplying device, such as belt, pulleys, gears, etc.

## THE ENGINE

**3. General Description.**—The engine is of the turbine type, compounding the steam four times, and may, therefore, be called a *quadruple compound turbine engine.*

It has no wearing surfaces in either steam chest or cylinder, and therefore requires no internal lubrication; hence, no sight-feed lubricator is provided for it in the cab. It has no reciprocating parts; hence, it can be, and is, perfectly balanced. While it provides an increased piston area for each succeeding expansion of the steam, as do all compound engines, it also provides a decreasing piston velocity, as the pressure of the steam is decreased by each successive expansion, the speed of the last pistons being equal to but 55 per cent. of the speed of the pistons against which the steam is first used.

In Fig. 1 is shown a vertical section, cut lengthwise through the machine, from which a very good idea of the construction and relative positions of the parts can be gained. The turbine wheel on the right, marked *2*, is fastened solidly to the main shaft *S* and contains four sets of buckets. The outer set *a* is at its extreme outer diameter, while the three remaining sets of buckets, marked *b*, *c*, and *d*, respectively, also in circular form, are inside the outer row. Each row of buckets, beginning with the row *a*, has a gradually decreasing speed, the peripheral speed of the last row *d* being but 4,000 feet per minute against 7,200 feet per minute on the outer row. The steam entering at *A* passes through two ports *f* in the governor stand *35*, strikes the face of the first row *a* of buckets, and as the wheel moves forwards, it allows the steam to exhaust or pass through the bottomless buckets into a series

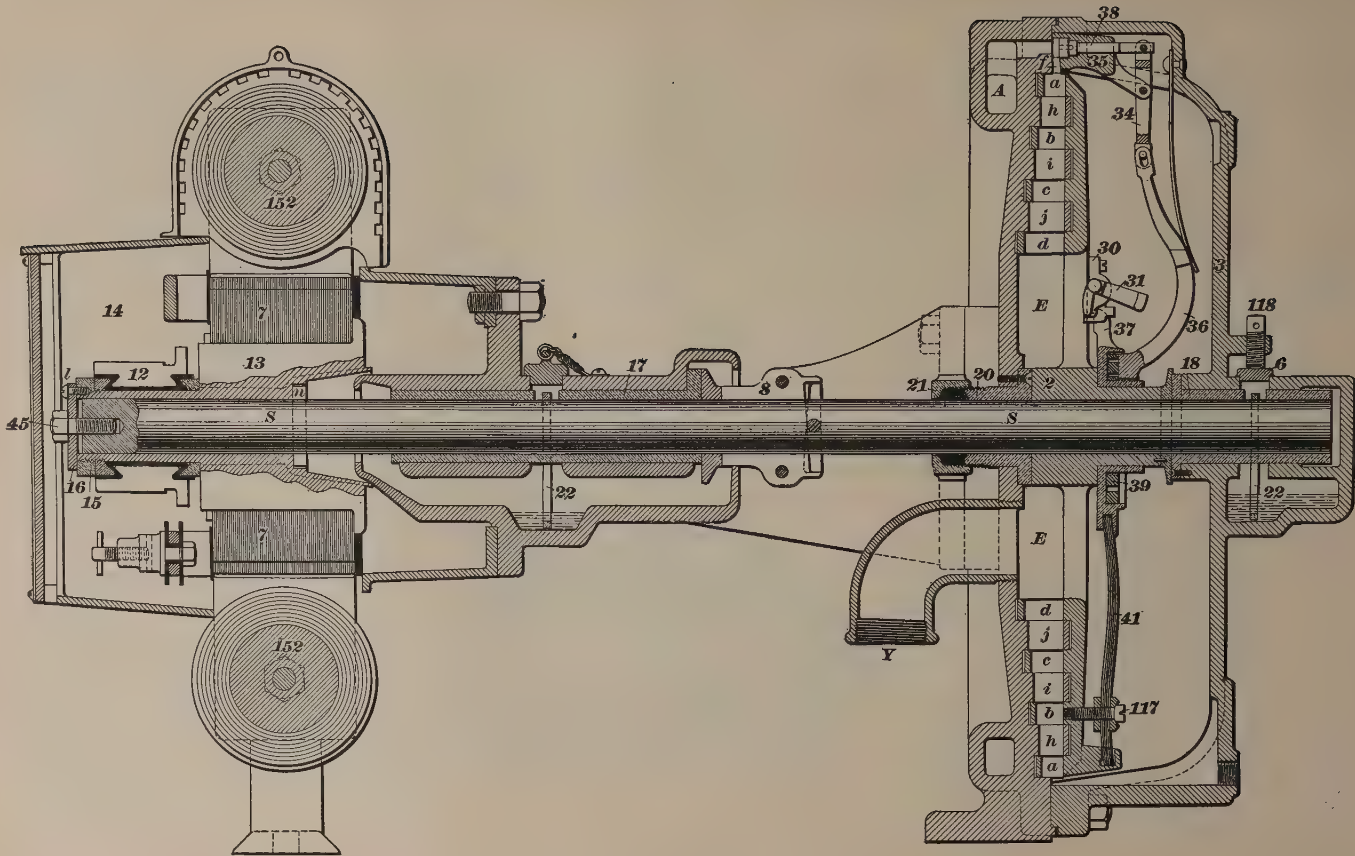

38
35
f
A
a
h
b
i
c
j
d
34
30
31
37
36
3
118
6
18
E
20
2
21
8
17
S
14
7
13
12
l
n
45
16
15
22
39
41
117
Y
152

FIG. 1

of stationary exhaust passages *h*, the direction of travel of the steam being, in a measure, reversed. These exhaust passages are so shaped as to change the movement of the steam into a forward direction again, and discharge it into the second row *b* of buckets, which, like the low-pressure cylinders of a compound locomotive, are of greater capacity than the first, and, in addition, are moving slower because of their decreased distance from the shaft *S*; a second force is thus exerted on the wheel. The steam exhausts from this second row of buckets into a second series of exhaust passages *i*, which causes it to impinge against the third row *c* of buckets. Exhausting again into a third series of exhaust passages *j*, it is directed against the fourth row *d* of buckets, the final exhaust being made into a central chamber *E* enclosing the main shaft and thence to the atmosphere through the exhaust *Y* shown just below the main shaft.

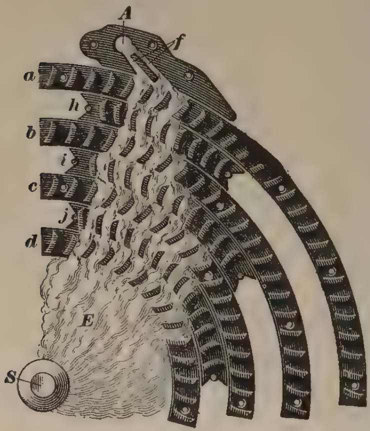



Fig. 2

**4.** By referring to Fig. 2, the manner in which the steam acts on the wheel can be seen. This view shows a section of one-quarter of the wheel, cut through from the outer edge to the center, the back half of the turbine being removed in order that the rows of buckets *a*, *b*, *c*, and *d* may be observed. The appearance and construction of the stationary exhaust passages *h*, *i*, and *j*, which direct the steam against their respective rows of buckets, are also shown. The final exhaust chamber *E* encircling the main shaft *S*, the admission port *A*, and the steam ports or passageways *f* in the governor stand *35* are shown. Diametrically opposite the steam inlet *A* and the exhaust passages *h*, *i*, and *j*, there is another steam inlet with a corresponding set of stationary

exhaust passages. The steam thus acts at two diametrically opposite points on the wheel, hence the wheel is in perfect balance; this arrangement eliminates those shocks found in an engine having reciprocating parts, the main shaft bearings carrying only the weight of the revolving parts. The general direction of the steam in its passage from port *A* to the exhaust chamber *E* is shown in Fig. 2.

The buckets *a*, *b*, *c*, and *d* are connected to the shaft *S*, and, of course, cause it to revolve with them; the exhaust passages *h*, *i*, and *j*, as already remarked, are stationary. This construction, therefore, offers no rubbing surfaces and does away with the necessity of admitting lubricant to the engine proper.

**5. The Engine Governor.**—The governor, Fig. 1, is of the well-known centrifugal type. The weights *31* (two in number) are simple bell-cranks that are connected to the wheel by the clamp *30*. The shorter end of the bell-crank *31* extends beneath the centerpiece *37*, as shown, and moves it out when the centrifugal force exerted on the longer end of the bell-crank is sufficient to overcome the tension of the governor springs *41*. This spring regulates the speed of the engine; the more rigid the spring, the more difficult is it for the weights, acting through the medium of the centerpiece *37*, cross-arms *36*, and connecting link *34*, to close the plunger valve *38* and thus partly throttle the admission of live steam through the ports *f* in governor stand *35*. Between the centerpiece *37* and the cross-arms *36* is the bearing ring *39*—a bronze ring filled with graphite. The graphite serves so well as a lubricant that, after several months' service, no appreciable wear can be noticed on the parts affected. The bushing *18* serves as a bearing to carry the steam end of the main shaft, the familiar oil ring *22* lifting the oil out of the oil cellar to the top of the shaft, where it passes to the bearing proper. Lateral motion is prevented by the end thrust *8* resting on bushing *17*, provision being made for taking up possible wear at this point. The bushing *17* serves to support the dynamo end of the main shaft,

this bearing also being provided with an oil ring *22* similar to that of the bearing *18*.

On the later makes of turbine engines there is applied a centrifugal brake shown in connection with Fig. 1. This brake is placed on the back side of the spoke of wheel *2* and

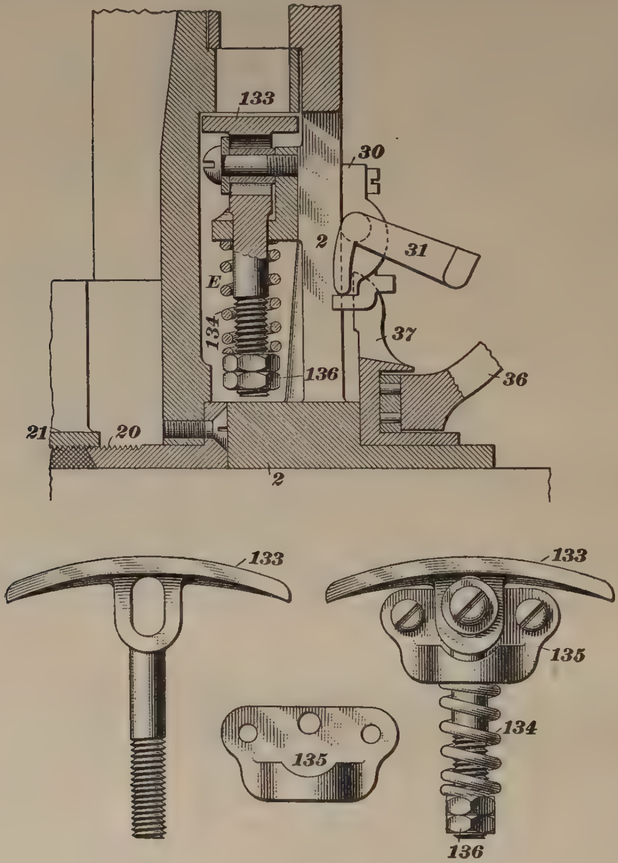



FIG. 3

should be set so as to act at about 100 revolutions per minute more than that at which the governor acts, so that, if for any reason, the governor fails to act, this brake will check the speed and hold it at any speed at which the brake is set.

When the speed of the engine gets too high, the centrifugal force moves the brake against the tension of its spring so that the shoe rubs against the inside of the case and the friction reduces the speed. The application of this brake will commence with equipment No. 2,600, but cannot be applied to equipments with serial number lower than that.

To adjust the centrifugal brake, remove the armature and the cap to engine, pull out the wheel and shaft and you have free access to the brake. If you wish to adjust the brake so that it will act at a higher speed, turn nuts *136* to the right, being sure to adjust both brakes the same; then tighten up the jam nuts. One half turn of the nut will change the speed at which the brake will act about 150 revolutions.

The stuffingbox *20*, covered by gland nut *21*, serves to make a tight joint where the main shaft leaves the exhaust chamber. This stuffingbox should be packed with wicking or other suitable material to prevent the exhaust steam from coming out along the shaft. There are oil holes in the nut to oil this packing. The governor must be kept in good condition. Should the governor in the older makes become inoperative when the engine is carrying a high pressure of steam, the speed is liable to become so high as to fracture the main wheel *2* by reason of the excessive centrifugal force that will be exerted on it.

The arc light will usually give notice of a high speed of turbine by burning with a green color and the supply of steam should be throttled until it burns white or the cause is remedied. If such a case is found, the governor should be reported at the end of the trip for adjustment.

## THE DYNAMO

**6. General Description.**—In the construction of the dynamo, particular effort was made to simplify all parts as much as possible. The armature *13*, Fig. 1, is held in place on the engine shaft *S* by the nut *15*, screw *45*, and washer *16*, all of which are prevented from working loose by means of a smaller screw *l* in the outer edge of the washer. The armature is caused to rotate with the shaft by means of a

dowel-pin *n* entering a suitable recess cut laterally into it from the shaftway.

The armature revolving at high velocity between the pole pieces 7 (which are connected by the upper and lower fields *152*), generates the electricity, which it delivers to the commutator *12*; from which it is connected by two brushes *B*, *B*, Fig. 4, one of which is shown in *B*, Fig. 5. These brushes, held in suitable brush holders *H*, Fig. 5, transmit the current to the lamp by aid of suitable wires insulated with a non-conducting covering. The improved brush holder in all its details is shown in Fig. 6.

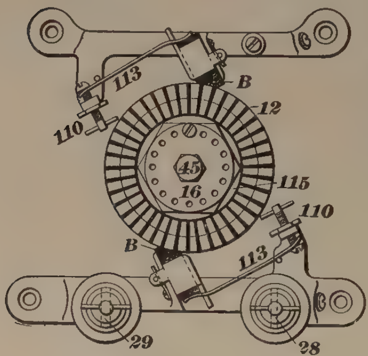



FIG. 4

The casing *14*, Fig. 1, protects the dynamo from dust and rain in the summer and snow and ice in winter.

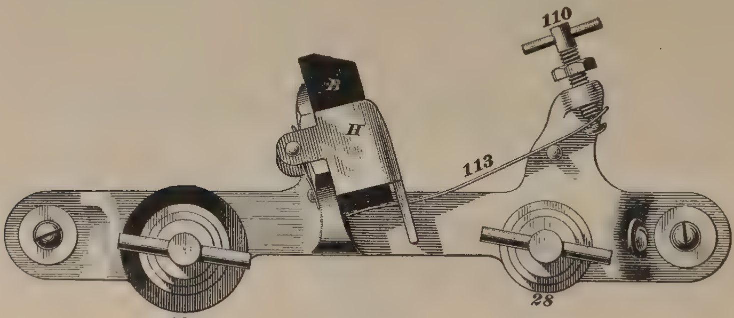



FIG. 5

The voltage, or pressure,* of the current generated by the dynamo is so low, about 35 volts, that it will not injure a

*The voltage, or pressure, of a current of electricity is the force that causes the electricity to flow through the wires, just as steam pressure causes steam to flow through pipes. The unit of steam pressure is the pound per square inch; the unit of electrical pressure is called the volt, which was named after Volta, a great Italian scientist.

person in the least; therefore, the operator need have no fear of receiving an injurious shock. In fact, no shock can be felt when direct and intentional contact is made. One thing should be clearly understood, however, and that is, a watch should never be brought closer than 18 inches to the dynamo,

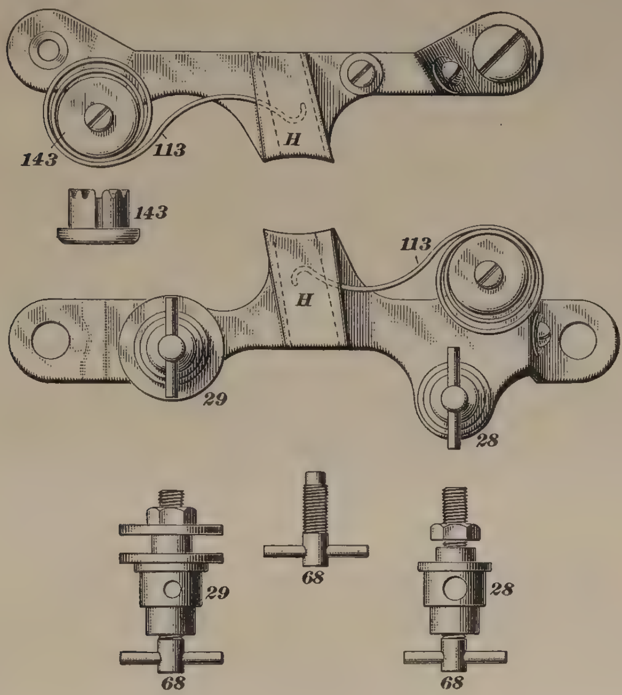



Fig. 6

as it is very apt to become magnetized, thus destroying its usefulness as a timekeeper until demagnetized. It is a good plan to keep your watch as far from the pole pieces of the dynamo as possible; then no harm can result.

## PRECAUTIONS FOR INSTALLING ENGINE AND DYNAMO

**7.** To insure a sufficient quantity of dry steam, the steam connection to the boiler should be 1 inch in diameter and the steam should be taken from the highest part of the dome. If the apparatus is placed just in front of the cab, the steam-supply pipe should be covered with suitable lagging, or, if placed close to the stack, it is advisable to run the steam-supply pipe under the jacket to avoid condensation. The turbine must have dry steam. If the pipe is not put under the jacket, it will be well to run it just inside the hand railing and on a line with it, in preference to carrying it down to the running board and then up again, as with the last-mentioned mode of piping it is impossible in cold weather to deliver steam to engine in proper condition. The exhaust pipe leading from *Y*, Fig. 1, to the smokebox of the locomotive should be $1\frac{1}{2}$ inches in diameter, and the discharge end should be about flush with the top of nozzle tips in front end. If a 2-inch pipe is used inside the front end, the exhaust will make less noise and will have a lighter action on the fire.

---

## CARE OF THE ENGINE AND DYNAMO

---

### CARE OF ENGINE

**8.** Though there are no wearing surfaces inside the engine to lubricate, an oil plug is placed in the top of the engine; this should be removed about once a week and three or four tablespoonfuls of engine oil poured in. This oil is not to lubricate the parts, but to serve as a preventive of corrosion. Mineral oils will remove and prevent rust much better than animal oils; hence, mineral oils alone should be used for this purpose. The main bearings *17* and *18*, Fig. 1, carrying the weight of the turbine wheel, armature, commutator, and shaft, require the best grade of oil, the heavier quality cylinder or valve oil being best adapted to this

service. Care should be taken not to fill the inside bearing *17* too full, as it will be thrown out of the end of the cellar on to the armature by the motion of the locomotive, and oil injures and eventually will ruin the armature. A quantity of oil sufficient to reach the ring *22* best answers the purpose; the ring carries it to the top of the shaft and the surplus falls back into the cellar. The outer bearing *18* should be filled each trip to about the height indicated in Fig. 1, and the plug *6* should be tightened down by the screw *118*, as exhaust-steam pressure reaches the oil supply in this bearing.

On the improved engines, this cellar has been supplied with a drain pipe to lead off the water that accumulates under the oil. Where this pipe is not used, some means of removing the condensation must be applied before the cellar is filled. It is very important that the casing be thoroughly drained before starting the engine, and that the steam be turned on slowly, so as to allow time for the removal of condensation and for the working parts to assume the natural positions incidental to changes of temperature before a high speed is attained. As the speed of all moving parts, both in the engine and the dynamo, is very high, it is essential that all bolts and screws be kept tight.

---

## SPEED OF ENGINE AND DYNAMO

**9.** Ordinarily, to obtain the proper results from the dynamo, a speed of 1,800 revolutions per minute should be maintained. With some dynamos, however, a speed of 1,900 or 1,950 revolutions per minute may be necessary, this variation being due to differences in the dynamos. To increase the speed of the engine, tighten the screws *117*, Fig. 1, that govern the tension of the springs *41*; to decrease the speed, slacken the screws. Every half turn of the screws, ordinarily, will increase or decrease speed about 50 revolutions per minute, but care should be taken to change all screws alike.

**10. Testing the Governor.**—To test the efficiency of the governor, pull out one of the wires that lead from the

dynamo to the lamp. If the speed increases to 2,500 revolutions or over, it indicates that the plunger valves *38* are cut and need refacing, so as to make a new and tight seat. This test should be made monthly to prevent the valves wearing to a condition that will admit of such high speed as to cause the fracture of the moving parts by centrifugal force. When engines are first put into service, particles of scale or molders' sand, which it is impossible to entirely remove, work in and cause the valves *38* to stick, interfering with the functions of the governor; the upper valve suffers most from obstructions of this nature. To overcome this trouble, it is advisable, after running the engine 2 or 3 hours when first set up, to take off the cap *3*, Fig. 1, and remove any dirt, scale, or sand that may have accumulated. If this is repeated on completion of first two or three trips, all danger from this source will be eliminated and no further trouble will result.

The governor should be examined once each month, and if plungers *38* are found cut they should be ground in or faced off as the case requires. If plungers are cut, the engine may run away and be broken by centrifugal force. If the plungers are faced off, the ends of the governor yoke should be bent farther out from the face of the wheel, thereby allowing the plungers *38* to again seat firmly before the governor weights *31* are thrown out farther than at right angles to the face of the wheel. If the speed is too high, adjusting screws *117* should be turned back half a turn each, being careful to adjust all the screws the same. Half a turn of these screws should change the speed about 100 revolutions per minute. If by turning back screws *117* the speed is not reduced, the plungers do not seat, and should be ground or faced off, as required.

---

### TAKING UP LATERAL MOTION IN SHAFT

**11.** When the amount of end play or lateral movement of the main shaft exceeds $\frac{1}{32}$ inch, it should be taken up as follows: Slack the screws in the thrust piece *8* and then,

looking lengthwise of the shaft and toward dynamo end of machine, tap the top part of the thrust piece toward the right until the end motion is sufficiently reduced. The proper amount of end thrust when the engine is warm and in working order is about $\frac{1}{64}$ inch.

## CARE OF THE DYNAMO

**12.** When the dynamo is working properly, no sparks should be seen at the brushes. The upper brush is made of graphite, the lower one, shown at *B*, Fig. 5, is of carbon. When it is necessary to remove these brushes for any cause, they can be taken out without disturbing the tension of the springs *113*. The tension of this spring, adjusted by the thumb nut *110*, should be just sufficient to hold the brush in such contact with the commutator as will prevent sparking; too much tension will result in undue wear and heating of the brushes and commutator. Ordinarily, the spring *113* will have the proper tension when the end supporting the brush will rise from $\frac{3}{16}$ to $\frac{1}{4}$ inch if relieved. This adjustment should be looked after daily, depending on the hardness of the brushes. The brushes should fit the commutator perfectly; if the fit is poor, or if the brushes do not make good contact with the commutator, they will spark badly.

If the commutator sparks badly and the sparking cannot be stopped by the adjustment of the springs, the commutator needs truing up or the brushes should be fitted to the commutator. To fit new brushes to the commutator, take a strip of No. 0 sandpaper about $1\frac{1}{2}$ inches wide, slip it between the commutator and brush with its rough side toward the brush, and then move it to and fro, as shown in Fig. 7, until the brush has been ground to a proper curvature.

If you find the commutator is running dark and has the appearance of being rough, it should be cleaned. To clean it properly, remove the brushes, tack a piece of No. 0 sandpaper on a board of the proper size, start the dynamo running, and then work the sandpapered board as you would a file, holding it level on the moving commutator. Do not attempt to just use the paper itself, or to hold the paper

with the fingers, as this treatment will probably do more harm than good, for when pressed down on the commutator the sandpaper will reduce the low spots as well as the high ones. Hold the paper, as shown in Fig. 7, with the sanded side next to the copper and it will usually give good results. No. 0 sandpaper should be used, but in no case should emery cloth or a file be used, for should a particle of emery or copper become embedded in the notches of the commutator

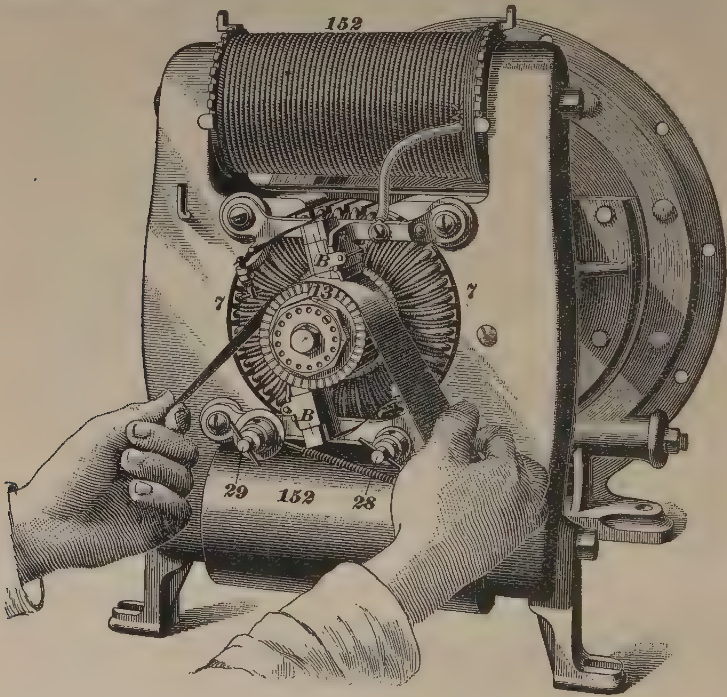



FIG. 7

it will cause a short circuit that will make trouble at once, as emery and copper are good conductors of electricity, while sand is a very poor one.

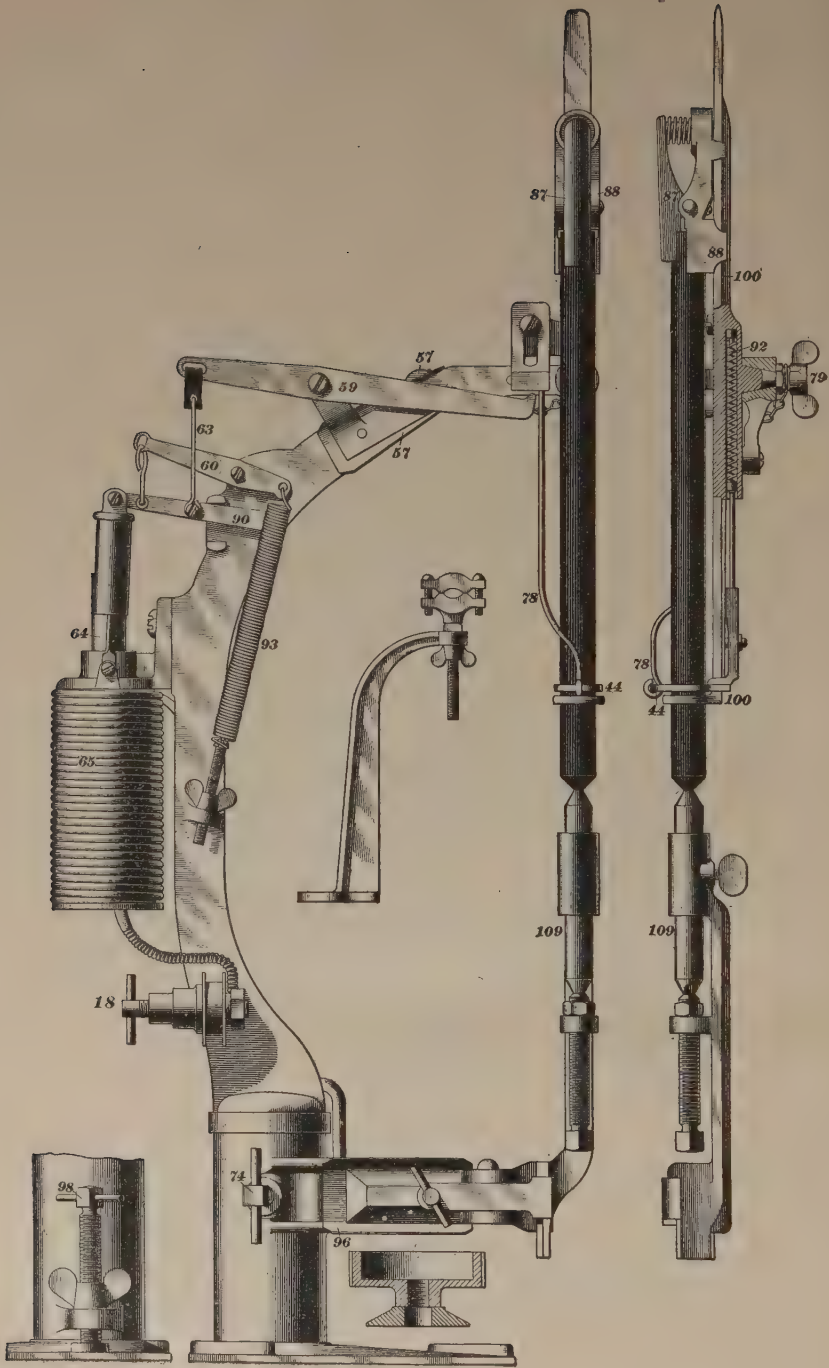
If the commutator becomes very rough or out of true, it should be trued up in a lathe, using a sharp tool and taking very light cuts. After turning a commutator down, polish it with sandpaper. After truing or cleaning a commutator,

care should be taken to see that the sections of the commutator are not connected by a burr or a piece of metal reaching across the strips of mica that separate the sections. The mica should be kept just a trifle below the surface of the copper as otherwise the copper will wear and allow the mica to project slightly, which will cause the brushes to vibrate so as to produce sparking. A common three-cornered file, ground to a proper point, makes a good tool to use in keeping down the mica strips. However, care should be used in handling it, for, if the mica is cut too low, the groove will collect dirt and cause a short circuit. Great care should be taken to leave no points or ragged edges that will cut away the brushes. Do not lose sight of the fact that the commutator is the vital part of the apparatus and requires care and attention. A daily cleaning, using a small piece of damp waste and rubbing lengthwise of grooves, afterwards finishing with dry waste, will remove dust from grooves and keep apparatus in good condition, and makes the smoothing up of the commutator unnecessary except at long intervals. The commutator should be cleaned by rubbing endwise and not around, so that the grooves will not have any dirt in them that will allow the current to pass across. In passing from the dynamo to the lamp, it is well to remember that ice, water, oil, and dirt are enemies of all electrical apparatus. Electricity will always take the easiest path, and foreign matter always stands ready to point the way. Keeping this in mind, the necessity of maintaining an uncompromising warfare on dirt should be apparent.

## DESCRIPTION AND OPERATION OF LAMP

### LAMP CONNECTIONS

**13.** The lamp is a self-adjusting arc lamp, and, if properly cared for and a clean reflector used, gives an intensely brilliant light. The wires used to convey the current from the dynamo to the lamp and back again, connect with the dynamo binding posts *28* and *29* in the lower brush holder, Figs. 4 and 7, and



87
88
87
88
100
57
92
79
59
63
57
60
90
78
64
93
78
44
44
100
65
109
109
18
74
98
96


FIG. 8

lead to two binding posts on the lamp. Unless the binding posts of the dynamo or lamp are removed and their positions changed, it is impossible to misconnect the wires between the dynamo and lamp, since the two wires are of different sizes. The holes in the binding posts also are of different sizes, to correspond with the wires they are to hold. The lamp, Fig. 8, has two binding posts, the right one, *18*, and the one on the opposite side of the lamp directly back of it, so that it is not seen in the figure. The positive wire from the dynamo connects with the left binding post while the negative wire—the wire that carries the current from the lamp to the dynamo—connects with the binding post *18*. The positive binding post has the largest hole through it. If the size of wire used for each side is the same, the ends of one of the wires should be doubled back at the ends for about an inch. This will keep this wire from going in the small hole, so that it can be used for one set of binding posts only.

If the lamp burns with a peculiar green hue, throwing little or no light, the current is reversed, passing through the lamp the wrong way. This may happen by reason of binding posts being removed and having their positions changed in replacing. At other times, the dynamo may reverse its current without apparent cause. This occurs but seldom and is caused by some radical changes brought about by exposure to strong magnetic influences. When the current is reversed through the lamp, the trouble can be readily overcome by reversing the position of the binding posts *28* and *29* in the lower brush holder, Fig. 4, putting post *28* in place of post *29*, and vice versa, taking care not to disturb the fibrous insulation under the posts.

If the speed of the dynamo is too high it will give a green color to the arc light, while the cab lights will burn with extra brilliancy.

---

### OPERATION OF THE LAMP

**14.** The current flowing from the dynamo enters the lamp at the left binding post, which, in Fig. 8, is behind the binding post *18*. From this, it passes through a No. 8

insulated copper-wire to bracket *57*; thence through the carbon holder *100* to the carbon, and through the copper electrode, its holder, and an insulated wire to the solenoid *65*; from here it goes to the binding post *18* and back to the dynamo through the return wire. The current, in passing through the solenoid, magnetizes it and attracts the solenoid armature *64*. This armature is connected by levers *90*, *60*, and *59* to clutch *44*, which clutches the carbon and pulls it up, thus separating it from the point of the copper electrode. As soon as this separation begins, the current must jump from the carbon to the electrode, and as the distance is increased the resistance offered to the flow of current increases. This weakens the current through the solenoid, which allows the armature *64* to be raised by the spring *93* until the distance between the carbon and the electrode points is properly adjusted to form the arc. As the carbon burns away, the distance from the carbon becomes greater, the current through the solenoid gets weaker, and spring *93* allows the carbon to feed to the proper amount for the arc.

---

### TRIMMING THE LAMP

**15.** Before starting the lamp, see that the point of the lower copper electrode *109*, Fig. 8, is clean and free from scale; this scale is formed when the lamp is idle, and should be removed with a file, maintaining an angle of about 45°, with a point $\frac{1}{8}$ inch in diameter. When this scale is allowed to accumulate, it acts as a non-conductor and prevents the current from passing through, and no light can be had until it is removed. This electrode also should be clean where it makes contact with the holder, as any foreign substance has a tendency to insulate the copper from the holder. If the copper electrode burns or melts off at the upper end, the equipment is running too fast and the speed should be promptly reduced by throttling the steam. As before stated, this is shown by a greenish instead of a white light from the arc. When satisfied with the condition of electrode *109*, a carbon should be put in by removing the carbon holders *87*

and *88* from the guide *100*. After securing the carbon in the holder, grasp it by the thumb and forefinger, with the remaining fingers resting on guide *100*; then it can readily be put in place. With a little practice, the lamp can be trimmed in a very few moments, and in the dark if necessary. After putting in a new carbon, always push down on lever *90*, Fig. 8, and notice if the carbon lifts and falls freely. If it does not lift, it is not in proper place in the clutch *44*; if it does not fall down freely, turn it around until a free movement is secured. A carbon should burn 8 or 9 hours. Before putting a carbon into the lamp, see that it is smooth, and that it is free from cracks, so it will work freely through the carbon holders. The best carbons are none too good for this service.

---

### REGULATING THE LAMP

**16.** The tension spring *93*, Fig. 8, serves two purposes: First, it brings together the points of the carbons so as to establish the arc when the dynamo is set in motion, a complete circuit being necessary to establish a current; if the carbons are separated but a fraction of an inch, the lamp will refuse to work, the current refusing to jump across the separation. The presence of oxidation or scale on the electrode will cause this separation of the carbons, though, to all appearances, an actual contact exists. Second, with the lamp properly trimmed, steam turned on, and the dynamo set in motion, the spring *93* performs its second function. As the current enters the lamp and passes through the solenoid *65*, the iron magnet *64* is drawn down, thus providing, through the medium of the lever *90* and lever *59*, for the necessary separation of the carbons. The spring *93* is connected to the end of lever *60* and exerts a force in the opposite direction to that of the solenoid. When this spring is properly adjusted, it prevents the solenoid pulling the carbons too far apart. If it is too strong, the magnet will be unable to pull the carbons apart and no light will be produced. This is noticeable when running with low steam pressure. If the dynamo is run long in this condition the heat generated by the current will be sufficient to burn out

the armature or field wires of the dynamo. If the spring is too weak, it will allow the solenoid *65* to separate the carbon and copper too far and thus break the arc. The lamp will alternately flash and then go out, on account of the magnet *64* being drawn down too far. When the light goes out, the current is broken and thus destroys the strength of the solenoid *65*, and the weak spring will draw down the carbon for a moment, reestablishing the current only to go out again. The spring should be adjusted to admit of the lamp flickering a little when the locomotive is standing; it will then be in shape to insure the maximum amount of light when the engine is running, and the light will burn steadily at that time.

If the lamp alternately flashes and goes out, it may be caused also by the carbon being very nearly burned out so that the holder *87* and *88* is down and touches the clutch *44*, in which case the jar of the locomotive will cause it to flash. Flashing can also be caused by a broken wire under the insulation, or by the insulation being worn off so that the bare wire can touch something that will make a short circuit, or by the wires being loose in the binding posts. If the light dies down when the locomotive is running very fast, it is an indication that the carbon is jarring through the clutch *44* faster than it is consumed and clutch spring *92* should be strengthened so as to hold the back edge of clutch from being jarred upwards and thereby releasing carbon. Or it may be that the spring *93* is a trifle too tight; this can be overcome by slacking the tension slightly.

When adjusting spring *93*, remember that the volume of light will depend to a great extent on the way you regulate the tension of this spring. A good rule is to adjust it as loose as possible and not have the light go out when the locomotive is stationary. To determine whether a failure exists in the dynamo or in the light, test it by laying a carbon across both binding posts on the dynamo; if a flash occurs when it is removed, the trouble is in the lamp.

**17. Adjusting the Clutch.**—If the carbon feeds too fast, the clutch rod *78*, Fig. 8, should be adjusted to take up

the lost motion or the excessive travel that prevents the clutch *44* from gripping the carbon properly. Sometimes this trouble can be overcome by removing the cotter pin in the carbon holder *100*, taking the spring out of the casing and stretching it to give it more set. By shortening the wire link *63*, the magnet *64* is held farther out of the solenoid *65*, thus giving the clutch a greater movement and causing it to clutch the carbon more firmly, which will prevent the jar of the locomotive, when on rough track, from shaking the carbon through the clutch faster than it burns. If this wire is made too short, however, the lamp will jump badly.

If the boiler is too full of water, the dynamo engine will get wet steam as soon as the throttle is opened to start the train. This will slow down the speed of the dynamo and the light will die down when train starts. The turbine will likely get dry steam when the locomotive is not working steam and the light will brighten up.

### FOCUSING THE LAMP

**18.** The lamp can be moved in all directions for focusing. The vertical focus regulates the distance at which the light will strike the track in advance of the locomotive. To get the proper vertical focus, loosen the setscrew *74*, Fig. 8, and move the lamp up or down by changing the adjusting screw *98*. To make the light strike closer to the engine, raise the lamp; to make it strike farther away, lower the lamp. To move it sidewise, backwards, or forwards, loosen the hand nuts above the foot-piece, placing the lamp in the proper position, and tighten them up in place. The light should leave the reflector in parallel lines, and, to secure this result, the point of the copper electrode must be as near the center of the reflector as possible, and it should be about 1 inch above the top of its holder. If it is any higher than this, it will be too close to clutch *44* and heat the clutch too much. Also, place the lamp so that the carbon will be directly under the center of the chimney hole. The back of the reflector is supported by an adjustable step for purposes of regulation. If any shadows are cast on the track, the

lamp is not focused properly, and, if in focus and the light does not strike the track as desired, move the headlight case on the baseboard. A very small movement will produce marked changes, a movement of $\frac{1}{8}$ inch changing the position of the light several feet on the track.

---

### SHORT CIRCUITS

**19.** Care must be taken to avoid short circuits. These are most liable to occur: (1) in the washers under the binding posts *28* and *29* of the dynamo, Fig. 4; (2) in the fiber *96* of the lower arm, or the fiber *57* of the upper arm, Fig. 8, of the lamp; and (3) in the insulation on the main wires, cab wires, etc.

If the arc light burns very dim and the dynamo engine is working very hard, with the cab lights burning very bright, the trouble is likely a short circuit in the arc-light wiring or in the lamp, or else the carbons are separated only a very short distance. If the wires leading from the small screws in the brush holders to the incandescent light in the cab come together, a short circuit may result and the light will go out. In that event, disconnect one of the small wires and look for the cause of trouble at your leisure. If this does not remedy the trouble with the arc light, look for a short circuit in the lead wires between the dynamo and lamp. If the carbon holder is pushed too far ahead and comes in contact with the reflector, a short circuit will result.

As before stated, scrupulous cleanliness will prove the greatest factor toward securing a perfect light. Engineers should give the headlight their personal attention for a few moments each day before making a trip. The commutator should be cleaned; a new carbon inserted when the old one is not full length; the point of the copper electrode cleaned; a proper supply of oil placed in the bearings; and all the screws tested to see that they are tight, especially those that hold the lamp in its proper position in the case and the binding screws *68*, Fig. 6, of the lead wires. The lead wires should be inspected to be sure that the insulation is not

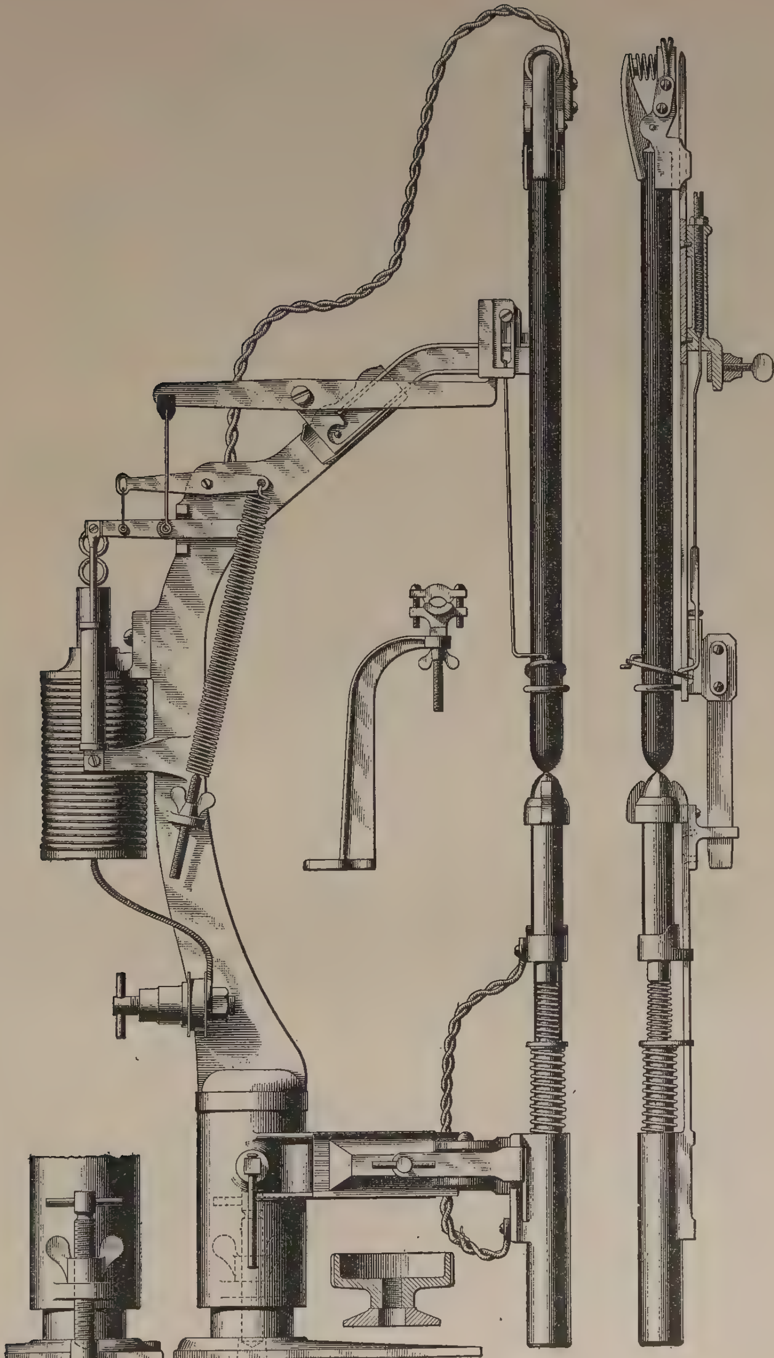


Fig. 9

worn off or that the ends do not stick through the binding posts and touch other parts of the equipment.

If the light does not start when steam is turned on the turbine and the turbine appears to be running at the proper speed, the point of the copper electrode should be examined to see if it is clean; next, see that the proper tension is on the brushes, and that the commutator is clean and the grooves free and clean. If these parts are all in good order, test for a short circuit in the lamp by placing a carbon across the binding posts.

When engines are pooled, some competent person should have the care of the lights. Reflectors should be cleaned the same as with oil lights. Carbons should be kept in a dry place and prevented from jarring around in boxes, causing fractures that lead to road failures. As all light generates heat, the trouble experienced by the cracking of the glass in the headlight case has been met by moving this glass 5 or 6 inches forwards of the usual position. Cutting the glass in two sections has also been practiced and an oval or bent glass will last indefinitely. Do not attempt to remove the reflector from the case until the wires have been disconnected and the top carbon holder *100* has been removed by loosening the thumb nut *79*, Fig. 8. Another style of lamp is shown in Fig. 9, but the foregoing directions apply equally to both styles.

---

## INCANDESCENT LIGHTS

**20.** A small number of locomotives have been equipped with a special incandescent circuit used to illuminate the running gear, etc. Where such an arrangement is made use of, a 16-candlepower incandescent lamp is placed inside of the reflector with the arc lamp. By means of a suitable switch, the arc light can be cut out and the incandescent lamps cut in, thus making it easier for opposing trains to approach, with the additional advantage of lighting up the exterior of the locomotive and materially assisting in case of breakdowns, etc. This circuit must be such as will offer the same resistance as the arc light. The switch is placed in the cab at some point convenient to the engineer.

# A SERIES OF QUESTIONS

## Relating to the Subjects Treated of in This Volume.

---

It will be noticed that the questions contained in the following pages are divided into sections corresponding to the sections of the text of the preceding pages, so that each section has a headline that is the same as the headline of the section to which the questions refer. No attempt should be made to answer any of the questions until the corresponding part of the text has been carefully studied.

# VAUCLAIN COMPOUND LOCOMOTIVES

## EXAMINATION QUESTIONS

(1) What is a compound engine?

(2) (*a*) How can the high-pressure cylinder of a compound be distinguished from the low-pressure cylinder? (*b*) Why is one cylinder called the high-pressure and the other the low-pressure cylinder?

(3) State the difference between a simple and a compound engine.

(4) Explain the operation of a Vauclain compound during both a forward and a backward stroke of the piston.

(5) Explain the duty of the starting valve of the Vauclain compound and describe its general arrangement.

(6) What advantage has the milder exhaust of the compound over the stronger exhaust of the simple locomotive?

(7) What should you do in the event of the breaking of: (*a*) a high-pressure piston rod? (*b*) a low-pressure rod of a Vauclain compound?

(8) For what class of service is a compound engine best adapted?

(9) Explain how that type of cylinder-cock lever of the Vauclain compound that operates the starting valve should be handled under different conditions of running.

(10) (*a*) Explain, in detail, how you would start a train with a Vauclain compound and bring it up to speed. (*b*) How would you handle it when drifting down a grade? (*c*) How would you handle it while on a heavy up grade?

(11) How should the reverse lever of a Vauclain compound be handled to obtain the best results?

(12) Why is it especially important that the cylinder cocks of compounds be open when starting a train?

# CROSS-COMPOUND LOCOMOTIVES

## EXAMINATION QUESTIONS

(1) What is a cross-compound locomotive?

(2) Explain how the cylinder lubricator feeds should be set for a cross-compound locomotive and give reasons.

(3) Why is an intercepting and reducing valve necessary in a cross-compound locomotive?

(4) What precautions should be observed with a Richmond compound when drifting?

(5) State how a Richmond compound should be handled in starting a train, both under ordinary conditions and when on a grade.

(6) State the duty of the automatic air-discharge valve of the Richmond compound, and explain how it operates.

(7) Explain the duty of the overpass valves in a Richmond compound and how they operate.

(8) Explain the operation of the reducing valve of the Schenectady compound.

(9) How should the reverse lever and throttle of a Richmond compound be handled to obtain the best results?

(10) What would you do in the event of a main rod on a cross-compound breaking?

(11) In the Schenectady compound, what is the duty of the oil dashpot and how does it operate?

(12) How great a tension should the reducing valve spring *s*, Fig. 9, of a Pittsburg compound have, and how is the tension of this spring regulated?

(13) How is the rapidity of movement of the oil-dashpot piston regulated in a Schenectady compound?

(14) Sometimes it is desirable to work a Pittsburg compound as a simple engine with the reverse lever not in the corner notch; how can this be done?

(15) Explain how a Schenectady compound is changed from compound to simple and again changed from simple to compound.

(16) What precaution should you observe with: (*a*) a Schenectady compound when drifting? (*b*) a Pittsburg compound?

(17) In the event of a main crankpin breaking on the high-pressure side of a Schenectady compound, how would you proceed to get the engine into a terminal?

(18) Explain how the intercepting valve of a Pittsburg compound is operated.

(19) If, with a cross-compound engine, standing with the high-pressure side on the center, the engine will not start when given steam, where would you look for the trouble?

# TANDEM AND BALANCED COMPOUND LOCOMOTIVES

## EXAMINATION QUESTIONS

(1) Explain how the cylinders of (*a*) a tandem compound, and (*b*) a balanced compound locomotive are arranged.

(2) Explain the operation of a Schenectady tandem compound when starting simple.

(3) Trace the course of the steam through the valves and cylinders of a Baldwin tandem when working compound.

(4) How would you proceed to test the high-pressure valve in: (*a*) a Schenectady tandem? (*b*) a Baldwin tandem?

(5) Explain how to test the piston-rod packing sleeve of a Schenectady tandem.

(6) How would you test the high-pressure piston packing in: (*a*) a Baldwin tandem? (*b*) a Schenectady tandem?

(7) How would you test the low-pressure piston packing in: (*a*) a Baldwin tandem? (*b*) a Schenectady tandem?

(8) In a balanced compound, what are the relative positions of the main rods as connected to the driving wheels and axles?

(9) How would you proceed in the event of a broken high-pressure main rod of a balanced compound?

(10) Explain how to test the high-pressure piston packing of a balanced compound.

(11) How would you test the low-pressure valve and piston of a Baldwin balanced compound?

(12) Explain how to test the low-pressure piston packing of a Schenectady balanced compound.

(13) What defect will cause one heavy exhaust: (*a*) When the exhaust beats occur at proper intervals? (*b*) When the exhaust beats occur at irregular intervals?

(14) Explain what precautions should be observed in operating a Baldwin balanced compound, when starting the train, running, and drifting.

(15) Explain what precautions should be observed under the same conditions with a Schenectady tandem.

# TRAIN RULES

(PART 1)

---

## EXAMINATION QUESTIONS

(1) Define a train.

(2) (*a*) What is a regular train? (*b*) May it consist of sections?

(3) (*a*) What are extra trains? (*b*) How are they designated in train orders?

(4) What is a superior train?

(5) How is right conferred?

(6) How are class and direction conferred?

(7) Which is superior: right, class, or direction?

(8) How may one train be made superior to another?

(9) Over what trains does class give superiority?

(10) How are the different sections of a train designated in train orders?

(11) What is a train of: (*a*) superior right? (*b*) superior class? (*c*) superior direction?

(12) What is a time-table, and what does it contain?

(13) (*a*) What is a pilot? (*b*) Is the pilot responsible for the movement of a train in his charge?

(14) What is the schedule of a train?

(15) What is a yard?

(16) What is a yard engine?

(17) Does a yard engine need a train order to work within designated yard limits?

(18) When a new time-table takes effect, what does it do?

(19) What will regular trains do, under Forms A and B of Rule 4, if on the road when a new time-table takes effect?

(20) When can a train created by a new time-table (that is, one not shown on the preceding time-table) start on its first trip?

(21) What is required of employes whose duty may require them to give signals?

(22) What signals must be used: (*a*) by day? (*b*) by night?

(23) When are night signals to be displayed?

(24) What do you understand by the initial point of a train on any division?

(25) (*a*) How many times may be shown for a train at any point? (*b*) When two times are shown, what is the earlier and what is the later? (*c*) When but one time is shown, which is it?

(26) How are the schedule meeting and passing points indicated on the time-table?

(27) When both the arriving and leaving time of a train are in full-faced type, what does it indicate?

(28) What are the different color signals used for?

(29) What does (*a*) red indicate? (*b*) white? (*c*) green and white combined?

(30) What sign placed before the figures of the schedule of a train indicates: (*a*) regular stop? (*b*) flag stop? (*c*) stop for meals? (*d*) leave? (*e*) arrive?

(31) What does green indicate?

(32) What is a fixed signal?

(33) What method is used for giving visible signals other than fixed signals?

(34) What is indicated when a hand, lamp, or flag is: (*a*) swung across track? (*b*) raised and lowered vertically? (*c*) swung vertically, in a circle, across the track, when train is standing? (*d*) swung vertically, in a circle, at arm's length, while train is running? (*e*) swung horizontally in a circle while train is standing? (*f*) held at arm's length above the head when train is standing?

(35) What is a fusee, and how is it used?

(36) What does a fusee indicate, and how must it be regarded: (*a*) when burning red? (*b*) when burning green?

(37) What does any object waved violently by any one on or near the track indicate?

(38) What are audible signals?

(39) What whistle signal indicates: (*a*) stop? (*b*) release brakes? (*c*) flagman, go back to protect rear of train? (*d*) flagman, return from west or south? (*e*) flagman, return from east or north? (*f*) train parted?

(40) How long should the signal for train parted be continued?

(41) What is the whistle signal: (*a*) to back the train? (*b*) to call for signals? (*c*) to call attention of other trains to signals carried for following sections?

(42) What is the whistle signal for: (*a*) approaching public crossings at grade? (*b*) approaching stations, junctions, and railroad crossings at grade?

(43) What does a succession of short blasts of the whistle indicate?

(44) (*a*) What does the explosion of one torpedo indicate? (*b*) What does the explosion of two torpedoes indicate?

(45) When two torpedoes are used as a caution signal, how far apart should they be placed?

(46) What means are used for conveying signals from the cars to the engine of a passenger train?

(47) What is the bell-cord or air-whistle signal: (*a*) to start the train? (*b*) to stop at once? (*c*) to back the train? (*d*) to stop at next station? (*e*) to apply or release air brakes? (*f*) to reduce speed? (*g*) to call in flagman?

(48) What light must be displayed at the front of every train by night?

(49) What must be done with the head-light when a train turns out to meet another, or is standing to meet trains at end of double track or junction points?

(50) (*a*) How should yard engines display head-lights? (*b*) When not provided with head-light at rear, what should be used?

(51) Should yard engines display markers?

(52) (*a*) What signals should be displayed at the rear of a train, and what are they? (*b*) What should be done with these signals when the train turns out to meet, or be passed by, another train?

(53) What signals should be displayed by the several sections of a train?

(54) What signals should be displayed by an extra train?

(55) When two or more engines are coupled to a train which of them should display signals?

(56) If only one signal is shown on the front of an engine when really two signals are required, what does it indicate?

(57) When cars are pushed by an engine, what should be displayed on the front of leading car?

(58) (*a*) What does a blue signal displayed at one or both ends of an engine, car, or train, indicate? (*b*) Who is

authorized to remove blue signals that have been displayed? (*c*) Should cars be placed on the same track so as to intercept the view of blue signals?

(59) What does a signal imperfectly displayed, or the absence of a signal at a place where a signal is usually shown, indicate?

(60) How are trains classified, and what are the respective rights of different classes?

(61) When does a regular train lose both right and class?

(62) When a train becomes twelve hours behind its schedule time, how can it be moved?

(63) What should be done before a train leaves its initial point or a junction, or passes from double to single track?

(64) How will a train proceed when leaving its initial point on any division, or a junction point, when a train of the same class in the same direction is due?

(65) What is required of an inferior train?

(66) What must be done by a train that fails to clear the main track by the time required by the rules?

(67) At meeting points between trains of the same class: (*a*) When must the inferior train clear the main track? (*b*) How should it take the siding? (*c*) If necessary to back in, what must be done?

(68) (*a*) At meeting points between trains of different classes, how much must the inferior train clear the superior train? (*b*) How much must an inferior train keep off the time of a superior train in the same direction?

(69) What should be done at schedule meeting and passing points, if the train to be met or passed is of the same class?

(70) When the expected train of same class is not found at the schedule meeting or passing point, how must the superior train approach all sidings?

(71) (*a*) If one train overtakes another that is disabled and cannot proceed, what will the first-mentioned train do? (*b*) What will the disabled train do?

(72) How will a regular train falling back on the time of another train of the same class be governed?

(73) How far apart must trains in the same direction be kept?

(74) By whose orders are: (*a*) train orders issued? (*b*) signals displayed for a following section? (*c*) extra trains run?

(75) When signals displayed for a following section are taken down at any point before that section arrives, what must be done?

(76) (*a*) How should trains approach end of double track, junctions, railroad crossings at grade, and drawbridges? (*b*) Where must all trains stop?

(77) When a train stops where it is liable to be overtaken by another train, what must be done?

(78) Give the flagging rule on the road you are employed on.

(79) When a flagman is recalled, what must he do?

(80) Who is responsible for the safety of trains?

(81) How must switches be left after being used?

(82) Who is responsible for switches used by a train being left in proper position?

(83) (*a*) If a train should part while in motion, what should be done? Explain fully. (*b*) What will a train coming up behind the detached portion of a train do?

(84) What should be done in case of doubt or uncertainty?

# TRAIN RULES

(PART 2)

## EXAMINATION QUESTIONS

(1) By whose authority and in whose name are train orders issued?

(2) To whom should train orders be addressed?

(3) Should train orders be accepted if they contain alterations, interlineations, or erasures?

(4) How many copies of a train order should be supplied by the operator to a train?

(5) (*a*) Name all the items required on a train order to make it valid? (*b*) How is a train order identified?

(6) (*a*) How are regular trains designated in train orders? (*b*) How are extra trains designated?

(7) What should the person receiving a train order do before signing it?

(8) Who should sign for train orders?

(9) (*a*) Who should deliver copy of train orders to enginemen? (*b*) What should the engineman do with an order on receiving it?

(10) (*a*) When a train order has been repeated or the X response sent before complete has been given, how must it be regarded? (*b*) Can the order be otherwise acted on until complete has been given?

(11) If the line fails before an office has repeated an order or sent the X response, how will the order be regarded?

(12) If a train finds a signal displayed on arrival at a station, and is informed by the operator that the line has failed before order was repeated or the X response sent, what will be required to release the train from that signal?

(13) How should an order be addressed that is to be delivered to a train at a point that is not a telegraph station?

(14) (*a*) What should the person do on receiving an order to be delivered in this manner? (*b*) How many copies should he receive, and what should he do with them?

(15) Whose signatures should he obtain on one of the copies?

(16) (*a*) When a train is named in an order, how much of it is included? (*b*) What does each section of a train require?

(17) If a train receives an order to meet a designated regular train at a given point, no sections being specified, and that train is found on its arrival to be carrying signals for a following section, what will the other train do?

(18) How long do train orders continue in effect?

(19) Can any part of an order be superseded or annulled? If so, how?

(20) What becomes of train orders held by regular trains, when such trains lose right and class, as by Rules 4 and 82?

(21) (*a*) What signal is used to stop trains for orders? (*b*) When this signal is displayed, what is required by trains?

(22) If the signal is not displayed at a night office, what must be done?

(23) When two or more trains are given an order to meet at a certain point as per Form A, what will they do?

(24) When two trains are given an order stating that one will pass the other at a designated point as per Form B, what will they do?

(25) When the order states that the following train will pass the other when overtaken, what will they do?

(26) When two trains are given an order stating that one will run ahead of the other from and to a designated point, what will they do?

(27) What should be the speed of the second-named train between the points designated?

(28) (*a*) If one regular train is given the right over another train in the opposite direction between designated points, as per Form C, how will they be governed? (*b*) If the trains meet at either of the designated points, which train should take the siding? (*c*) If they meet between the designated points, which train should take the siding? (*d*) If the second-named train reaches the point last named in the order before the other arrives, what will it do? (*e*) If the second-named train, before meeting the other, reaches a point within or beyond the limits named in the order, what will they do?

(29) (*a*) If the order states that a specified extra train has the right over a designated regular train from and to designated points, how will each train be governed? (*b*) When is the order fulfilled?

(30) If the order states that a specified work extra has right over all trains between designated points, what right does the order confer on it?

(31) Can other trains go within the work-train limits until the order is annulled?

(32) (*a*) If an order is given stating that regular trains have right over a designated regular train between two designated points, as per Form D, what right does it confer on the regular trains receiving it? (*b*) How will the regular train designated in the order be governed?

(33) (*a*) If an order is given stating that a certain train will run a given time late from and to designated points, as per Form E, how will it be governed? (*b*) How will other trains receiving this order run with respect to the train named in the order?

(34) (*a*) If an order is given stating that a certain train will wait for another train at a designated point until a specified time, as per Form E, how will it be governed? (*b*) How will the second-named train run with respect to the time shown in the order?

(35) (*a*) If an order is given stating that a designated engine will run extra from and to designated points, as per Form G, what right does it give? (*b*) Is the train receiving this order required to protect against extra trains?

(36) (*a*) If an order is given stating that a designated engine will leave a certain point at a given time and date and run on a schedule embodied in the order, with right over all trains, as per Form G, what right will it have? (*b*) If the order specifies particular trains over which the extra is given the right, what will it do? (*c*) How will trains over which the extra is thus given right be governed?

(37) (*a*) If an order is given stating that a designated work extra will work from a specified time until a specified time between designated points, as per Form H, what right does it give? (*b*) If to this order an addition is made requiring this train to keep clear of, or protect against, a designated extra after a specified time, what will they do? (*c*) How will the extra train named in the order be governed?

(38) If an extra train receives an order requiring it to protect against a designated work extra between two designated points, how will the first-named train be governed?

(39) (*a*) If the words "protecting itself" be added to the working order given to a work extra, how will it be governed? (*b*) How will other extra trains receiving this order run with regard to the work extra?

(40) (*a*) If an order is given stating that a designated work extra will protect against a certain regular train between designated points, what right does it confer? (*b*) How will the regular train named in the order be governed?

(41) (*a*) To whom are holding orders addressed? (*b*) How must they be regarded by trainmen and enginemen?

(42) When a train is so held, what is necessary before it can proceed?

(43) (*a*) Will any orders received by a train, addressed to the train, release it from a holding order? (*b*) To whom should the order permitting it to go be addressed?

(44) (*a*) If an order is given stating that a designated train is annulled, what does it do? (*b*) How will other trains be governed?

(45) Can a train once annulled be restored under its original number?

(46) (*a*) If an order is given stating that a designated order is annulled, what does it do? (*b*) Can the order thus annulled be reissued under its original number?

(47) When part of an order is annulled, how does it affect the remaining portion?

(48) When an order is superseded by another, what effect does it have on the first order?

(49) Can an order that has been superseded be restored under its original number?

(50) At what time of the day do you generally find that a new series of train-order numbers begins?

(51) (*a*) For what purpose should a clearance card be used? (*b*) Name all the items required to make a clearance card valid.

# CAR LIGHTING

## EXAMINATION QUESTIONS

(1) Give a brief general description of the Pintsch lighting system.

(2) (*a*) What do you understand by "a pressure of 10 atmospheres"? (*b*) How many pounds per square inch is this pressure equivalent to?

(3) What are the duties of the following parts: (*a*) Holder valve? (*b*) Main cock? (*c*) Filling valve? (*d*) Regulator?

(4) What is the disadvantage resulting from a burnt and chipped reflector, and what is generally the cause of same?

(5) (*a*) Give, in detail, the operation of charging up a car for the first time. (*b*) How do you make the connection between the charging line and the car? (*c*) With what pressure would you test a car, and how would you do it?

(6) What effect does improper checking of the burners have?

(7) (*a*) What is the effect of dirt lodging in the burner tips? (*b*) How would you remedy the same?

(8) (*a*) What produces an unsteady or wavy light? (*b*) Where would you look for the cause of trouble?

(9) Describe, in detail, the adjustment of the gas burners.

(10) (*a*) Explain, in detail, the operation of lighting up a train. (*b*) What is the proper way to extinguish the lamps?

(11) In what cases are two main cocks used on a car, and where are they located?

(12) If you suspected the existence of leaks in a car equipment, how would you proceed to locate the same?

(13) (*a*) How would you proceed to clean out the piping on a car? (*b*) Would you, under any circumstances, connect the regulator outlet with piping under high pressure? Give reasons for your answer.

(14) (*a*) On what cars is a double line of roof piping often used? (*b*) How, in such a case, can one line be cut out without interfering with the other?

(15) At what pressure should the gas be when supplied to the lamps, and how is this reduction of pressure (below that in the holder) brought about?

(16) What is the objection to extinguishing the lights in a car by closing the main cock?

(17) Why is it important to keep the glass bowl, dome, reflectors, and mica clean?

(18) How is the gas supply turned on and off in the filling valve?

(19) How are the pressure gauges used in the Pintsch system graduated?

# CAR HEATING

## (PART 1)

---

## EXAMINATION QUESTIONS

(1) Give a brief outline of the Baker system of heating.

(2) Explain how the Baker heating system is filled with water and what precautions are necessary to get all the air out of the pipes.

(3) Why is salt water used instead of fresh water in the circulating piping?

(4) (*a*) How would you test the circulation? (*b*) If it had stopped for some time in freezing weather, how could you readily ascertain the fact?

(5) What would you do if a safety vent blew out?

(6) Trace the course of the water in the Baker system from the time of leaving the heater coil until entering it again.

(7) After refilling the drum, in what position should you leave the funnel *f*, and why?

(8) What are the conditions usually met with that destroy the circulating action?

(9) How can you test the height of water in the circulating drum?

(10) (*a*) Where is the device known as the safety plate and gas preventer used? (*b*) What is it for?

(11) What is a direct-steam system?

(12) Trace the progress of the steam in the Gold direct system from the time it leaves the boiler until it escapes from the train, after performing its duty of heating.

(13) (*a*) In the Gold system, what is the purpose of the steam trap placed under each car? (*b*) Why is it provided with a sediment well and a blow-off valve?

(14) (*a*) Describe the operation of heating a cold train with direct steam. (*b*) How would you regulate the heat? (*c*) How should the various valves be left when cutting out a car?

(15) How is the heat of the steam communicated to the water in circulating pipes of the Gold hot-water system?

(16) (*a*) What is the steam-storage system? (*b*) Is it a direct-steam or a hot-water system?

(17) Describe, briefly, the apparatus in the storage system.

(18) Why should all the valves in a direct-steam system be left open when the steam is cut off from the train pipe?

(19) Explain the construction and operation of the Gold vertical trap.

# CAR HEATING

(PART 2)

## EXAMINATION QUESTIONS

(1) Describe, briefly, the Safety Company's direct-steam regulating system.

(2) In the case of a train heated by hot water, what preparations would you make when approaching a station at which the engine was to be cut off for some time?

(3) What would you do in the case of a hot-water system that would not circulate properly, but in which the water level was found to be correct?

(4) Describe the Safety Company's direct-steam system No. 1.

(5) Describe, briefly, the scheme of the Consolidated Company's direct-steam system.

(6) (*a*) How would you heat the cars and regulate the heat in the Consolidated Company's direct-steam system? (*b*) How would you manage the drainage? (*c*) How would you work the drain valves in very mild weather?

(7) How would you blow obstructions out of the piping of the Consolidated Company's hot-water system?

(8) How would you heat a train with the Safety Company's hot-water system, and how would you regulate the temperature?

(9) Describe the construction and operation of the Safety Company's vertical trap.

(10) Trace, briefly, the course of the steam and also of the circulating water in the commingler system.

(11) What is the duty: (*a*) of the dial cock? (*b*) of the trap cock?

(12) What would you do if circulation stopped through shortness of water?

(13) Describe the various steps of cleaning out the commingler system—the piping, fittings, and commingler.

(14) (*a*) What part does the device known as the commingler play in the system? (*b*) Describe its construction.

(15) If, in a train equipped with the commingler system, it became necessary to heat certain of the cars by a fire in the Baker heater, how would you prepare for same?

(16) What would you do if, although the steam was on as usual, you found the car getting cold?

(17) If it is intended to fill the expansion drum at the next stop, what cocks should be opened or shut in advance, and why?

(18) (*a*) From where was the air supply drawn in the early installations of the water-raising systems? (*b*) What were the objectionable features of such practice?

(19) (*a*) From where is the air drawn in the modern water-raising systems, and at what pressure does it enter the water tank? (*b*) Why is a low pressure used, and how is it obtained?

(20) Assuming governor *q* and reducing valve *r* to be in proper order, what troubles are likely to arise in the water-raising system shown in Fig. 26?

(21) What bad results would ensue if the stop cock *l*, Fig. 26, were not tight on its seat?

(22) (*a*) Explain, briefly, the action of the system shown in Fig. 26. (*b*) How would you refill the water tank?

(23) How would you test to see if the governor *q* and the reducing valve *r*, Fig 26, were in good condition?

(24) (*a*) What would you do if, on opening the cold-water faucet, Fig. 26, air came out, but no water? (*b*) What would you do if neither air nor water appeared?

(25) If, on opening the hot-water faucet, Fig. 26, neither air nor water appeared, what would you do?

(26) Explain the operation of the governor used with this system.

(27) For what pressure should the governor be adjusted? Why?

# ELECTRIC HEADLIGHT

## EXAMINATION QUESTIONS

(1) (*a*) What precautions should be observed in turning on the steam when it is desired to put the headlight in operation? (*b*) Why is this precaution necessary?

(2) How many times does the turbine engine expand the steam?

(3) (*a*) What precautions should be observed in filling the oil cellar on the dynamo end of the main shaft *S*, Fig. 1? (*b*) What kind of oil should be used in these bearings?

(4) Fully describe how to clean the commutator.

(5) Why is it essential that the mica strips in the commutator be kept a trifle below the surface of the copper sections?

(6) (*a*) What kind of oil should be introduced into the turbine engine, and how often and in what quantities should it be supplied? (*b*) What is the object of introducing oil into the turbine?

(7) What would be the effect: (*a*) if the brush springs were too tight? (*b*) if they were too loose?

(8) What should be the tension of the spring *93*, Fig. 6, when the locomotive is standing still?

(9) If the light dies down when the engine is running, and you find the trouble to be elsewhere than in the tension spring *93*, where would you look for it?

(10) How would you proceed to take up end play in the main shaft, and what amount of play should this shaft have when the engine is warm and in working condition?

(11) (*a*) If the light burns green, what does it indicate? (*b*) How would you remedy the trouble?

(12) At what speed should the dynamo be run?

(13) Explain how you would test the engine governor.

(14) Why do the valves *38*, Fig. 1, sometimes stick when the apparatus is first put in service?

(15) Is it essential that the scale which forms on the copper electrode be removed daily? Give reasons for your answer.

(16) How would you test to determine whether the trouble was in the lamp or the dynamo, if you could not get the lamp to burn?

(17) If the carbon jars down when the engine is running on rough track, that is, if it feeds too fast, how would you remedy the trouble?

(18) What precautions must be taken before removing the reflector from the headlight case?

(19) Explain how to adjust the centrifugal governor on steam engine: (*a*) to increase the speed; (*b*) to decrease the speed. (*c*) How many revolutions will be gained or lost by turning the regulating screws one half turn? (*d*) Is it essential that the tension of the screws be the same?

(20) Why should emery cloth or a file never be used on the commutator?

(21) At what points is a short circuit most liable to occur, and what effect will a short circuit have?

(22) Describe a method of fitting a new brush to a commutator.

(23) If the copper electrode melts and burns, what is the trouble and how would you remedy it?

(24) (*a*) If the light strikes the track too close to the locomotive, what would you do to remedy the trouble? (*b*) If too far away, what would you do?

(25) Should shadows be cast on the track, where would you look for the trouble?

# INDEX

NOTE.—All items in this index refer first to the section and then to the page of the section. Thus, "Blows 20 33" means that blows will be found on page 33 of section 20.

## F



## G

T